UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

ANNOTATED DRAFT PROVISIONAL AGENDA

77-1-0124

ANNOTATED DRAFT PROVISIONAL AGENDA

1. Election of officers

A President, two Vice-Presidents, and a Rapporteur will be elected to officiate at the meeting.

2. Adoption of the agenda

The provisional agenda will be considered for adoption. Agenda items 4 and 5 are identical to the two substantive items proposed for adoption in the provisional agenda for the United Nations Conference on Desertification.

3. Arrangements for the United Nations Conference on Desertification

The substantive preparations for the Conference will be reviewed.

4. Processes and causes of desertification

The General Assembly in its resolution 3337 (XXIX), on international co-operation to combat desertification, in calling for a United Nations conference on desertification to be held in 1977, asked for "an assessment of all available data and information on desertification and its consequences on the development process of the countries affected, through the enlisting of all the expertise available from public and private institutions and organizations of Member States, including on-going and planned research, studies and activities within the United Nations system".

To respond to this request, four component reviews dealing with climate and desertification, demographic, social and behavioural aspects, ecological change and desertification, and technology and desertification are being prepared. These will be background documents for the Conference and will be synthesized in an overview which will be a principal document for the Conference and will be before the regional meeting in provisional form. It is also expected that the world desertification map requested by the General Assembly will be discussed under this item. A number of case studies on desertification in specific locations in different countries are being prepared for the Conference, together with a synthesis of them. It is expected

/that those

that those that have been carried out in the region will be before the meeting.

In addition to provisional or advance copies of the documents for the United Nations Conference on Desertification, the regional meeting will have before it, under this agenda item, a selection of country papers prepared by Governments in the region whose countries have experienced desertification. These papers will enable the meeting to share experience on the extent and degree of success of programmes to arrest desertification. Related to these papers will be a statement submitted by the Executive Secretary of the Economic Commission for Latin America describing the nature and extent of desertification in the region. In addition, a review of United Nations activities relating to desertification, prepared by the Environment Co-ordination Board, will be available as a background document.

5. Draft Plan of action to combat desertification

The General Assembly in calling for the Conference recommended in its resolution that the international community urgently take concrete measures to stem the spread of deserts and to assist the developing countries affected by the phenomenon to ensure the economic development of the areas affected. The General Assembly also recognized the urgent need to prepare a world integrated programme of development research and application of science and technology to solve the special problems of desertification in all its ramifications and reclamation of land lost to desertification. The resolution further expressed the conviction of the General Assembly that work in this field should be carried out at the national, regional and global levels through studies and meetings at the appropirate technical levels, and that an intergovernmental conference on desertification would provide the international community an opportunity to launch a broad plan of action with a view to resolving the problem of desertification.

A draft of the Plan of Action will be before the meeting for review. It is expected to contain a short term plan of activities that should be undertaken immediately as part of a longer range plan

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6. Adoption of the report of the meeting

A report which, it is expected, would not exceed five pages will be considered for adoption. Together with the reports of other regional meetings, it can be made available to the United Nations Conference on Desertification as a background document (and also to the next meeting of the regional commission).

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UNITED NATIONS CONFERENCE ON DESERTIFICATION

DESERTIFICATION: AN OVERVIEW

FIRST DRAFT

ITEM 4

OF THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETING FOR

THE AMERICAS

Santiago, Chile, 23-26 February, 1977

Secretariat of the United Nations
Conference on Desertification
P.O. Box 30552
Nairobi, Kenya

January, 1977

GE.77-82178

UNITED NATIONS CONFERENCE ON DESERTIFICATION

DESERTIFICATION: AN OVERVIEW

FIRST DRAFT

SUBMITTED FOR DISCUSSION AND COMMENT TO
THE REGIONAL PREPARATORY MEETINGS
FOR THE CONFERENCE

ITEM 4

OF THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETINGS FOR

THE AMERICAS
Santiago, Chile, 23-26 February, 1977

AFRICA SOUTH OF THE SAHARA
12-16 April, 1977

THE MEDITERRANEAN AREA
Algarve, Portugal, 29 March-2 April, 1977

ASIA AND THE PACIFIC
New Delhi, India, 19-23 April, 1977

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NOTE TO THE REGIONAL PREPARATORY MEETINGS FOR THE UNITED NATIONS CONFERENCE ON DESERTIFICATION

The attached Overview is presented to the Regional Preparatory Meetings for the United Nations Conference on Desertification for discussion and comment in conformance with Item 4 of the Draft Provisional Agenda for those meetings.

The Overview has two primary purposes to which discussion and criticism should be directed:

(1) It should provide a readable but scientifically accurate summary of the causes and processes of desertification and of the steps that can be taken to combat such processes and, where possible, reverse them.

(2) It should provide justification for the recommendations contained in the proposed Plan of Action to Combat Desertification, a draft of which will be discussed under Item 5 of the Provisional Agenda for the Regional Preparatory Meetings.

Comments made at the Regional Preparatory Meetings will be taken into account in the preparation of the final draft of the Overview.

The soil which kept breaking away from the highlands ..... keeps continually sliding away and disappearing into the sea ..... What now remains, compared with what existed, is like the skeleton of a sick man, all the fat and soft earth having wasted away and only the bare framework of the land being left ..... What are now mountains were lofty, soil-clad hills; the stony plains of the present day were full of rich soil, the mountains were heavily wooded -- a fact of which there are still visible traces. There are mountains in Attica which can now support nothing but bees, but which were clothed, not so very long ago, with fine trees suitable for roofing the largest buildings -- and roofs hewn from the timber are still in existence ..... The country produced boundless pasturage for cattle.

The annual supply of rainfall was not lost, as it is at present, through being allowed to flow over the denuded surface into the sea, but was received by the country, in all its abundance, into her bosom, where she stored it in her impervious clay and so was able to discharge the drainage from the heights into the hollows in the form of springs and rivers with an abundant volume and a wide territorial distribution. The shrines that survive to the present day on the sites of extinct water supplies are evidence for the correctness of my present hypothesis.

-- Plato
The Critias

PREFACE

In December 1974, the United Nations General Assembly passed resolution 3337(XXIX) calling for an international Conference on Desertification, to be held in 1977. The General Assembly specified that to prepare for this conference a world map should be developed showing areas vulnerable to desertification, all available information on desertification and its consequences for development should be gathered and assessed, and a plan of action to combat desertification should be prepared with emphasis on the development of indigenous science and technology. In a subsequent resolution 3511(XXX), the General Assembly stressed the need "for additional research to clarify a number of fundamental problems of desertification".

This additional research took the form of case studies directed toward key aspects of the desertification process. Six such case studies were financed and carried out by the specialized agencies of the United Nations system. They analyzed the process of desertification in (1) Chile and (2) Tunisia, both with predominately cold-season rainfall, in (3) India and (4) Niger, both with predominately warm-season rainfall, and in (5) the Indus Valley and (6) the Tigris-Euphrates Valley, both irrigated areas subject to waterlogging and salinization. In addition, a number of Governments co-operated by developing associated case studies focused on desertification problems within their borders. These governments include Australia, China, Iran, Israel, the Soviet Union and the United States.

Another set of studies relates to the possibility of co-operative, transnational efforts to combat desertification. These so-called feasibility studies, prepared by specialists, concern the construction of greenbelts on the northern and southern rims of the Sahara, the management of groundwater aquifers in northeast Africa and the Arabian peninsula, the monitoring of desertification processes in South America and the Middle East, and livestock and rangeland management in fragile, dryland ecosystems.

The accumulation of the currently available information on desertification may be said to include the requested desertification maps. A world map of areas vulnerable to degradation was prepared by UNESCO and FAO at a scale of one to 25 million and maps of the desert areas of north Africa and South America have been prepared at a scale of one to five million. In addition, some of the case studies were accompanied by more detailed maps of the areas under consideration.

To present the available information in a coherent way, the broad subject of desertification was broken down into four major elements, and recognized specialists were commissioned to write a review of each element. The authors of these four component reviews received the advice and assistance of an international panel of experts. The review are entitled Climate and Desertification, Ecological Change and Desertification, The Demographic, Social and Behavioural Aspects of Desertification, and Desertification Technology.

This Overview seeks to provide a brief account of the main findings of the four component reviews. To do so properly, it has sometimes gone beyond the component reviews, as, for example, in making reference to the case studies and the feasibility studies. Limited in length, the Overview cannot be regarded as a summary of all aspects of desertification. Its viewpoint is more specifically directed to showing how the elements of the Plan of Action to Combat Desertification, as submitted to the conference, emerge directly from the information presently available and from past efforts to combat desertification, as carried out in many parts of the world. In the same sense, the Plan of Action has served as the focal point around which all preparations for the conference have been organized.

The four component reviews, together with the Overview, represent an attempt to provide the delegates to the Conference on Desertification with a more organized kind of documentation. It is the hope of the Conference Secretariat that the delegates will find this system more useful and convenient than the more customary procedure of providing an extended catalogue of documents each of which covers one miniscule aspect of the subject under consideration.

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I

The Problem of Desertification

The Sahel - a region at risk

In the Sahel, as in other drylands, rainfall is scanty and highly variable. For as long as history remembers, nomads have pastured their herds in the arid grasslands that rim the southern edge of the Sahara desert; they have seemed suitable for little else, since only nomadism can take full advantage of the fact that the rain, unreliable as it is, may fall in one place and not in another. Yet even so, the pastoralists of the Sahel live under the constant threat that the rains, such as they are, will fail, and that the land will be affected by drought. Major drought struck the Sahel in 1913 and again in 1940.

This great drought, 1968-1973

In 1968 it happened again. At Rosso in western Mauritania, which receives an average (1935-72) of 284mm of rain a year, only 122mm fell in 1968. This seemed at the time to be a mere quirk in the as yet unpredictable weather patterns, since the rainfall returned to normal in 1969 with 295mm. But in 1970, the rains failed again with a mere 149mm, then again in 1971 (126mm) and worst of all in 1972 (54mm). By 1973 the situation in the Sahel was catastrophic. It provided a spectacle of death, disease and migration that served as the immediate stimulus for the 1974 call by the United Nations General Assembly for international co-operation to combat desertification, including a world conference on desertification to which a plan of action would be submitted.

What had happened to the Sahel by 1973, the fifth year of drought? Lake Chad had shrunk to one-third its normal size. In the preceding winter, the great Niger and Senegal rivers had failed to flood, leaving much of the best cropland in five countries (Niger, Mali, Upper Volta, Senegal and Mauritania) cracked and barren. The water table dropped, drying up shallower wells throughout the Sahel's five million square kilometres and placing the nomadic pastoralists in deadly peril. After consuming the last accessible shreds of dried-up vegetation, famished herds were sold, slaughtered or driven southward in a fruitless search for pasture. Behind them was a stripped landscape, baking in the sun, where patches of newly-created desert seemed to grow and link up, producing an impression that the great Sahara desert was "marching southward".

Also by 1973, the last year of the drought, a large programme of international assistance had been mounted for the distressed countries of the Sahel. Contributions, in cash, but mainly in food, by Governments, the United Nations system and private individuals approached a value of $200 million by 1974. This was emergency relief, primarily intended to prevent starvation. It could do little about the destruction of the agricultural base of five countries (Mauritania, Upper Volta, Mali, Niger and Chad), already among the poorest nations in the world, and severe damage to the agricultural base of two other (Senegal and Gambia). For these countries, the destruction of

agriculture meant a loss of their tax base and a situation close to bankruptcy. In the absence of reliable statistics, especially difficult to obtain among nomadic peoples, it is not easy to say how many people died as a direct result of the drought but estimates have ranged between 100,000 and 250,000. That the toll of death was not higher could be attributed only to the relief programme. The amount of drought-induced disease is also impossible to calculate precisely. Malnutrition was rife among children, especially among the nomads, and outbreaks of measles took on epidemic proportions. The loss of livestock was appalling, with estimates reaching as high as 90 per cent in Mali.

Climatologists are asking whether the prolonged drought in the Sahel signified a long-term climatic shift to more arid conditions in this immense territory that supports 25 million people. But a review of recorded climatic fluctuations in the area has led to a conclusion that the Sahelian drought, however severe and however unexpected it may have seemed to the inhabitants of the Sahel, must probably be regarded as a predictable event under the climatic regime that existed formerly, something to be expected at long intervals, perhaps two or three times a century.

The great drought in the Sahel also gave rise to a number of other questions. Can such occurrences be predicted so that people can prepare for them? What should be done to see people through such successions of lean years, in the form both of emergency relief and long term actions? What are the best rehabilitative measures to be applied after such an event? These questions are the more pertinent because the Sahel drought coincided with rainfall failures, loss of crops and livestock, and famine and death in other parts of the worlds drylands, including particularly East Africa and the deserts of Pakistan and India.

Drought and desertification

The drought has ended and favourable rainfalls have returned to the Sahel since 1974, but at least a decade will be required to restock the pastures and at least as long again before the ravaged land returns to something like its former state. It is this long-term spread of desert conditions in formerly more productive lands that we call desertification, to distinguish it from the temporary climatic phenomenon of drought.

Desertification is far from a novel experience for mankind. It has been a major factor in the destruction of human civilization from the earliest times. For example because of improper drainage, salts concentrated in the lands irrigated by the Sumerians and Babylonians, thus destroying their agricultural productivity. Prolonged and intensifying desiccation of the land ruined the agricultural basis of the Harappans, who had constructed a pre-Aryan civilization in what is now Pakistan. The Mediterranean littoral of Africa was certainly more productive in Roman times than it is today.

It is possible that the area lost to man's use in this way may be of the same order of magnitude as the total amount of land left in crops or pasture today. There is general agreement that the rate of loss of land or productivity through desertification has increased significantly during the last decades to the order of almost 50,000 km. squared per year and that 30 million km squared are vulnerable to desertification in a world likely to be faced increasingly with food shortages.

Although deserts are not without life, they can be viewed as areas with extremely limited agricultural potential. There is a variety of desert types, hot and cold, stony and sandy, but all are characterized by rainfal deficiencies so marked that cultivation or stock-rearing are possible only with special adaptations. Desertification, as the extension or intensification of desert conditions, diminishes the productivity of the land, and it is this which makes it fundamentally a human problem. Desertification affects the whole global community; for example lowered wheat yields in the drylands affect all who depend on wheat as food. But the human impact of long-term desertification is far greater on the people who live where it is happening and who depend upon arid lands for their livelihood, particularly in the developing countries. There desertification can bring poverty, malnutrition and disease, erosion of the economic base, and the further deterioration of social services already hampered by remoteness and the uncertainty of the environment. It breaks up families and may wipe out whole cultures. It lowers resistance against the impact of succeeding droughts, each of which may bring famine, death and the collapse of livelihood systems, and each of which in turn tends to advance further that degradation which is implied in process of desertification.

The wide *impact of* desertification

Vulnerability to desertification and the severity of its impact are partly governed by climate, in that the lower and more uncertain the rainfall, the greater the threat of desertification, but other natural factors also come into play, such as the seasonal occurrence of rainfall, as between hot season and cool season, the structure and texture of the soil, the topography and the types of vegetation to be found. Additionally, liability to desertification increases as pressures on the land increase, as reflected in density of population or livestock, or in the extent to which agriculture is mechanized.

Areas regarded as subject to desertification on these various grounds are shown on the World Map of Desertification. It shows that areas assessed as being at high or very high risk occupy most of the arid and semi-arid regions and extend into adjacent subhumid zones. Neglecting the extreme deserts and the very cold deserts, which are severe and little-used environments unlikely to undergo further significant deterioration, there remains an area of potentially productive but threatened drylands covering 30 million square kilometres, or 19 per cent of the earth's land surface. These occur so widely that at least two thirds of the 150 nations of the world are directly affected. Through its sheer extent, therefore, desertification is shown to be a global problem.

everyone with adequate food shelter and clothing is now recognized as an urgent world problem, one that will increase in difficulty as the world's population continues to expand. Efforts to resolve this problem without the enormous output of the drylands would be tinged with the most sombre prospects. The world simply cannot afford to abandon its drylands to desertification.

The drylands also serve as reserves sheltering an important range of plant life, including the genetic material from which have been developed many of mankind's staple grains - wheat, barley, sorghum and maize. The Green Revolution has focused new attention on the critical importance of this botanical heritage, particularly as a resource which can be used to keep highly cultured strains, such as the so-called "miracle wheat", resistant to destruction by disease. As ecotypal reserves of a variety of interesting and useful natural settings, the drylands constitute a precious human heritage. In recent years, they have come increasingly to serve as areas to which people go - and where they often remain - in quest of health and recreation.

Land and people already affected

But desertification is more than a threat. A great many people live in drylands that are now undergoing desertification, and their livelihoods are already affected. It is difficult to determine how much land is being lost to agriculture at the present time, but there is no question that a great deal of once-productive land is currently being lost to desertification. Widely accepted estimates place the annual loss of arable land alone at between five million and seven million hectares. This would be from all causes - road construction, industry and urban expansion as well as grazing and cultivation. Other estimates are more pessimistic, suggesting that the world will lose close to one-third of its arable lands by the end of the century if losses continue at the present rate. Such losses, of course, are taking place at a time when populations are growing rapidly, with the expectation that the food requirements of the human race will rise by at least one-third, and probably more, by the end of the century. Further, if cultivable land be valued at an average of $1,000 per hectare, then the annual loss would amount to $50 million, a sum far in excess of the predicted costs of the programmes to combat desertification. Of course losses may be in pasture valued at much less than arable land. But as the desert encroaches on pasture on one side, arable land on the other is degraded to pasture, keeping total losses close to the estimate.

Unfortunately some of this land has already deteriorated to the extent that for all practical purposes, rehabilitation is economically impossible.

The numbers of people immediately threatened, their general location and livelihood systems, are as follows:

TABLE 2

ESTIMATES OF POPULATIONS AND LIVELIHOODS RESIDENT IN AREAS RECENTLY UNDERGOING SEVERE DESERTIFICATION 1/
(in thousands)

Region	Total Population	Urban Based	Agriculture Based	Animal Based	Area (km^2)
Mediterranean Basin	9 820	2 995 31%	5 900 60%	925 9%	1 320 000
Sub-Saharan Africa	16 165	3 072 19%	6 014 37%	7 079 44%	6 850 000
Asia and the Pacific	28 482	7 740 27%	14 311 54%	6 431 19%	4 361 000
Americas	24 079	7 683 32%	13 417 56%	2 979 12%	17 545 000
	78 546	21 490 27%	39 642 51%	17 414 22%	30 076 000

1/ As estimated by H. Dregne (includes both severe and very severe categories)

Of these 78 million, about a third may be in a position, because of income or other circumstances, to avoid the worst consequences of desertification. This still leaves about 50 million people who are immediately menaced by malnutrition and disease, the destruction of their livelihoods, the collapse of such social services as health care and education, and by the grim prospect of uprooting themselves from everything familiar and of migrating to other areas usually ill-equipped to receive them.

Urgency of the problem

This review of the problem shows that desertification is more than a global threat to the people of the drylands and to the world community in general; it is an active process already destroying the land and livelihood of tens of millions of people. The need for action to combat desertification is all the more urgent because the process is a dynamic one, self-accelerating as it feeds on itself. With delay, rehabilitation becomes increasingly lengthy and expensive, and degradation may relatively rapidly reach a threshold beyond which it is irreversible in practical and economic terms. Fundamental preventive measures should be introduced as soon as possible in the form of land-use practices which are both socio-economically and environmentally appropriate, and which prevent desertification from making its first encroachments.

II

Processes of Desertification

Water and energy balances

To see precisely what happens when desertification occurs, attention should be focussed on that shallow interface where soil and atmosphere meet, and where a balance must be maintained between incoming and out-going energy and between water received and lost.

When rain falls, some of the water is taken up directly by the plants, some infiltrates into the soil, where it may remain in storage, and the rest evaporates or runs off. Some soil moisture, and that intercepted by the plant, is breathed back into the atmosphere, by the plants in transpiration, and some of the soil moisture may seep into deeper layers to collect in underground reservoirs or aquifers.

The soil-air interface also shares in an energy balance activated by the rays of the sun or through atmospheric heating. Some energy is reflected back into the atmosphere and into space. Some is held by the soil in storage, thereby warming the earth, and it is this energy and that from the sun directly that is used by the plants to carry out the processes of photosynthesis and growth. Some of the plants are eaten by grazers or browsers, and these in turn may be eaten by carnivores, with all animals returning energy and moisture to the atmosphere in respiration. The excreta of animals, their decomposing carcasses and the decomposition of plants supply the soil with nutrients, most densely in the topmost layers and thinning out below.

(These relations are illustrated in the following diagrams.)

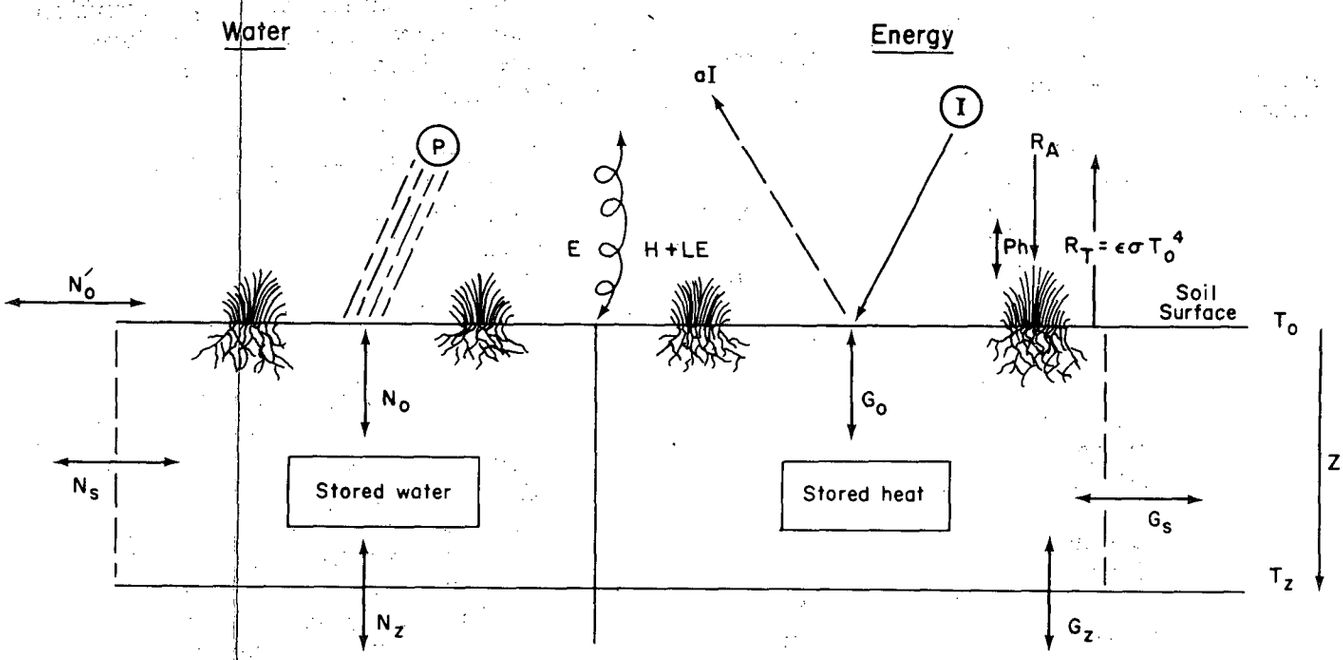
Adaptation to the arid environment

In arid situations the cycling of water and energy takes on special characteristics because of deficient and variable rainfall and abundant solar energy from cloudless skies. Vegetation is generally sparser than in humid areas, provides less cover to the ground surface and returns less organic matter to the topsoil. During occasional intense rainfalls runoff may occur in spate, and in the long intervening dry spells the surface is parched and heated by the powerful sun.

Despite its sparsity however, the dryland vegetation constitutes a fundamental resource which transforms solar energy into food and which also protects and stabilizes the ground surface. It survives by adapting to water deficit in ways which are important because they determine seasonal differences in the usefulness of dryland pastures.

Part of the plant population consists of short-lived ephemerals which germinate and complete their life cycle rapidly after rain, remaining as seed through intervening dry periods. Such plants are commonly fleshy and palatable and are preferred by grazing animals. Other plants, such as perennial grasses, wither and die back to the root stock in dry spells and shoot anew with fresh rains. These plants form more durable pastures and are attractive and palatable for stock when green, and may provide valuable hay,

Figure 1



ter exchanges are on the left, energy on the right. The diagram refers a partly vegetated surface whose temperature (for radiative emission d convective forcing) is T_0. Most natural surfaces in dry climates ve extensive areas of bare soil, as shown.

e water exchanges are forced by precipitation, P, a very intermittent put. The water reaching the surface may percolate, N_0, or run-off at e surface, N_0'. The soil layer, of depth z, stores water - typically order 10 cm of precipitation when wet. If storage is full, the maining rainfall may outflow laterally, N_s, or percolate to ground ter. With high water tables on sloping sites, N_0', N_s and N_z may all verse, so that there is run-on. Total water surplus $N = N_0' + N_0 + N_z$. there is no change in storage, $P = N + E$, where E is the evapotransration.

e energy exchanges are forced by global solar radiation, I, direct hadow-casting) plus diffuse, a fraction (a, the albedo) of which is flected, aI. The surface temperature is mainly a function of the sorbed solar radiation $I(1 - a)$. There is diffuse infrared radiation ceived from the atmosphere, R_A, and infrared is emitted from plants d soil, $R_T=\epsilon\sigma T_0^4$, where ϵ is the emissivity (usually >0.9), σ is the éfan-Boltzmann constant, and T_0 is surface temperature. $-R_T + R_A$ is e net longwave heating, generally negative. The net radiation is $= I(1 - a)-R_T + R_A$. A small part of R, G_0, is conducted to the soil, ere it may be stored. If level z is the depth at which there is no nual temperature cycle, $G_z = 0$, and G_s is negligible. Hence G_0 virally vanishes over the year. The remaining heat, $R - G_0$, feeds conctive fluxes, H of heat, and LE of latent heat. If $T_0 < T_A$ (air temperature), H is negative, though small, and LE may also be negative (dew formation). In this case the convective fluxes force the net radiation, rather than the reverse - the typical nocturnal condition. Ph is the net photosynthesis, generally 2 orders of magnitude smaller than R (see component review on ecological change). If there is no change in storage, and no net synthesis, $R = I(1-a) - R_T + R_A - G_0 = H + LE$.

Note that a, the albedo, is a function of the state of the vegetation and soil, tending to rise from values near 0.17 in fresh green savanna to ~0.35 in sandy deserts (Oguntoyinbo, 1974). Degradation of vegetation in general raises the albedo, as does drying the surface. Absorbed solar radiation, and hence surface temperature T_0, are functions of a, as are net longwave cooling $(R_A - R_T)$, the soil heat flux G_0, the convective fluxes of heat and latent heat, H + LE, and net photosynthesis, Ph. Hence changes in albedo drastically alter the entire energy and water balances.

Increases in soil compaction due to overstocking, use of vehicles, drought contraction or pan formation decrease the infiltration rate, and hence increase N_0' at the expense of N_0, so increasing the chance of sheet erosion and gullying. They also alter the thermal conductivity, and hence G_0. These processes are discussed in the component review on ecological change.

T_0 is low by day when the soil is moist, and higher when it is dry - by 20 to 30C in tropical conditions. With moist soil and low surface temperature, R is large, and the Bowen ratio H/LE is very low - of order 0.10. With dry soil and high surface temperature, R is lower, and the Bowen ratio rises to very high values.

but are of little pastoral value when thoroughly dried out. Nevertheless their extensive fine root systems remain to bind the topsoil and contribute importantly to its organic food store. Lastly, there are the longer-lived perennial plants which resist water loss by adaptations such as woody stems and leathery leaves. These naturally include the larger plants such as shrubs and trees. They are often nutritious and provide an important food source to browsing animals during the dry periods, although their adaptations may reduce their palatability and attractiveness for some stock, and they have the additional and essential role of protecting the ground surface and preserving an environment which favours the response of important shorter-lived plants. It is this function that is threatened when desert pastures must support large stock numbers during drought.

Impact of land use on equilibrium on dryland ecosystems

Under natural conditions and through appropriate strategies, the dryland ecosystems maintain a balanced exchange of water and energy, but this equilibrium is readily disturbed by man's use of the land. For example where meagre vegetation is further reduced to expose the ground surface, rain falling directly on the soil may form a thin crust which prevents water from sinking. As the water budget deteriorates in the soil beneath, the level of groundwater in nearby wells may fall. The water lost to the soil store now contributes to over-rapid runoff, and where the surface is loose or disturbed the topmost soil layer, that with the best structure and containing the bulk of plant food, may be washed away, or blown away in dust storms. The denuded soil is increasingly exposed to the direct rays of the sun and its reflectivity may increase, with strong heating at the soil-air interface. All these changes constitute a change towards a more hostile environment for plants, with the result that the vegetation responds less well to rains and produces less nourishment, and many plants will tend to die off at an increasingly early stage of drought. Such changes constitute desertification.

Drought as an engine of desertification

In its initial stages, desertification may merely involve a shift to a more desert-like and less productive ecosystem, with water and energy balances less favourable to plant growth than before. But land use in arid regions poses problems which continually menace the prevailing equilibrium. This is primarily because of fluctuations in rainfall between drought and abundance which, not yet predictable, are difficult for the land user to respond to effectively. For example, in dryland pastoral economies, large numbers of stock tend to build up during runs of good years, far too many to be supported through the inevitably ensuing drought. There is a natural reluctance to cut back on stock numbers in the first dry year, and a tendency to hang on until drought is seen to be established. But by this time dryland pastures are probably being ravaged by overgrazing beyond hope of complete regeneration, while the last shreds of plant cover are being trampled to death and the soil pulverized and rendered vulnerable to wind erosion in mini-deserts around watering points or wherever stock congregate. By this time too,

prices for surplus stock will probably have shrunk and destocking through sale of surplus numbers will be opposed by economic forces. The unwanted solution, death of livestock, may become inevitable. Thus the delayed response of the land user through cycles of good and bad rainfall may convert periodic drought into a true engine of long-term desertification.

The main processes and stages of desertification can be summarized as follows. Initially, and especially in dry periods, there is a deterioration in the composition of desert pastures subject to excessive grazing, particularly a reduction in the proportion of edible perennial plants and an increase in the proportion of inedible invaders usually with less resistance to drought. The thinning and death of vegetation in dry seasons increases the extent of bare ground, and this is followed in turn by a deterioration in the soil-surface conditions vital to plant growth, particularly an impoverishment of plant-water relations. The response of ephemerals to rain suffers accordingly. With consequent increase in runoff, sheet and gully erosion set in on sloping ground, and the topsoil and its organic store are lost. All these changes mean a decrease in productivity, palatability and durability of the native pastures. With continuing erosion, formerly productive lands may be lost through soil stripping and gully extension, or through siltation in valley bottoms. These changes are even more drastic where devegetation occurs in strategic areas, as on watershed uplands, and the processes are naturally advanced where soils are exposed and disturbed in dryland cultivation.

Wind and water erosion work together, as stripped surfaces and redeposited silt are increasingly liable to wind transport. The finer soil particles, including organic plant food, are blown away as dust, and the coarser fragments are drifted along as sand, which may accumulate into dunes, locally helped where shrubs trap the moving sand. Not only are shifting sands sterile and difficult to colonize by plants, but as advancing dunes they may overrun and destroy valuable nearby cropland.

As soils dry out with desertification, soluble salts are no longer so readily leached away and may concentrate near the surface through evaporation. Salinization and alkalinization of soils may eventually exclude all but worthless vegetation and advance the process of erosion by causing the soil to crack and crumble. This desertification phenomenon is naturally most developed, and most costly in its consequences, on poorly drained irrigated lands, where salts introduced by irrigation cannot be leached from the soils.

Desertification feeds on itself

Desertification tends to be self-reinforcing, to feed on itself, as soils denuded of plant cover are stripped to impervious, sterile horizons or powdered to fine dust. Biological degradation is followed by accelerated physical erosion by wind and water. Comparatively easy to deal with in its initial stages, desertification becomes increasingly difficult to treat as the process advances,

with the costs of reclamation rising exponentially, until the stark equilibrium of extreme desert is reached and the land has for all practical purposes passed beyond hope of rehabilitation.

The advance of desertification

The spatial dimension of such changes can be seen in a progressive extension of desert lands, as subhumid areas take on a semi-arid character and semi-arid ecosystems deteriorate to arid status. In considering the area under threat, we must therefore include the subhumid margins of the deserts, as well as the semi-arid and arid regions. Only the hyperarid areas of extreme desert may be considered beyond care; elsewhere, combative measures are called for to halt and reverse the processes of desertification, and conservational management of the land to maintain productivity.

The advance of desertification should only rarely be thought of in such theatrical images as dunes advancing over productive soil. It is usually a more insidious and irregular progress, and for that reason more difficult to come to grips with. It seems to attack on all sides, with areas of degraded vegetation or denuded soil developing here and there, far in advance of any nebulous 'front line'. This is because arid lands are patchworks of small environments of differing vulnerability to desertification as determined by local topography, soil and microclimate, and it is the more vulnerable pieces that first succumb. As desertification proceeds, the denuded patches may link up and the desert extends, but more like a skin disease than as a wave-like front.

III

The Causes of Desertification

Desertification is a problem of interaction between a difficult and unreliable dryland environment and the impact of man's use and occupation of it in his efforts to make a living. Some understanding of the controls of dryland climates helps towards an appreciation of climatic factors in desertification.

The desert belts

Although their boundaries have shifted over time, deserts must always have characterized the earth's subtropical zones. Global patterns of air circulation dictate that the subtropics are regions of subsiding air. When air subsides it warms up and its capacity to hold moisture increases, so inhibiting the formation of rain. This accounts for a prevalence of dry climates between latitudes 15 and 25 degrees north and south of the equator. However the dry climates are extended and their patterns complicated by additional factors, such as distance from the rain-supplying oceans or mountain barriers which spill air downward on their lee sides, creating rain shadows.

The play of these factors is evident in the distribution of deserts as shown on the World Desertification Map. There are five main desert belts: (1) the Sonoran Desert of northwestern Mexico and its continuation in the desert basins of the southwestern United States; (2) the Atacama desert, a thin coastal strip running west of the Andes from southern Ecuador to central Chile, whence dry climates extend eastwards into Patagonia; (3) a vast belt running from the Atlantic Ocean to China and including the Sahara, the Arabian desert, the deserts of Iran and the USSR, the Rajasthan desert of Pakistan and India, and the Takla-Makan and Gobi deserts in China and Mongolia, (4) the Kalahari and its surrounding deserts in southern Africa, (5) most of the continent of Australia. Outside these principal desert regions there are isolated patches of very dry lands in many parts of the world, such as the Cuajira Peninsula in Colombia, southwestern Madagascar and part of northeastern Brazil. Within the desert belts there are many climatic contrasts resulting from differences in temperature, from season when rain falls (if any) and from degree of aridity. At one extreme are the intensely cold deserts such as those of Siberia or the Tibetan plateau, where occupation is precluded by low temperatures and where the environmental degradation is accordingly small. On the other are hot deserts such as the inner Sahara, where plant growth and land use are absent because of hyperaridity. These extreme deserts do not concern us - they are not subject to further desertification - and they remain unclassified, in neutral grey on the World Desertification Map.

More extensive than the extreme deserts are the world's arid lands, those with up to 200 mm of rain falling annually in definite seasons, with sufficient vegetation to support extensive pastoralism, although necessarily on a nomadic basis in the drier parts. Outside these are the semiarid lands, with as much as 600 mm of rain, depending on temperature and season, where cultivation of drought-resistant crops

is generally possible with the use of moisture-conserving practices. Finally, on the greener margins of the dryland belts are the drier parts of the subhumid zones, where land use and settlement become more intensive, but which must be considered as ultimately threatened if desert conditions are permitted to extend. Altogether the usable drylands occupy 45.6 million square kilometres, or 30 per cent of the world's land area. It is here, where desertification is taking place, that its causes must be sought.

Shifting limits of dryland climates

Despite figures on areas, it is evident that the boundaries of the dryland belts are not fixed eternally on the map. Much of the Sahel for example consists of old sand ridges, now quite fossil under cover of vegetation, which indicate a former extension southwards of Saharan climates and moving sands, some 500 km beyond their present limit, about 20,000 years ago. In the same region, Lake Chad was much more extensive 10,000 years ago, indicating semiarid or subhumid conditions in what is now arid. These climatic changes have been shown to be part of global shifts of the climate belts, relating to changes in the earth's atmospheric circulation. They are linked to the great changes of the Ice Age and of subsequent millenia, during which temperature shifts are known to have been accompanied by changes in rainfall patterns.

Such changes, with durations of several centuries, have continued and have directly affected the possibilities of man's occupance and use of the drylands in the past. For instance much of the presently hyperarid Sahara was open to pastoralists and hunters under semiarid conditions about 8,000 years ago. Unfortunately the definite records of later changes are mainly from higher latitudes and give temperatures rather than rainfall; from 1600 to 1850 for example those latitudes in the northern hemisphere underwent a cooling known as 'The Little Ice Age', then followed a warming which continued into the 1940's, since when temperatures have again declined. It is being suggested that this cooling may mark the resumption of another 'Little Ice Age' in the north.

Climatic change as a cause of desertification

From this arises the question: "Do recent droughts in the Sahel and elsewhere form part of a change to a more arid climate, expressed as an equatorward shift in the limit of the dryland belt?" Those replying yes would note that over the same period deficiency of rainfall in the drylands was compensated by greater rainfall in the wet equatorial belt. The consequences would be that the dryland inhabitants would face a long period of increased aridity in their part of the world following a century or more of relatively favourable climate. It would imply that man might be a victim of recently accelerated desertification rather than its active agent. Clearly the answer to the question has great significance for strategies to combat desertification.

Unfortunately the question cannot be answered with confidence because the events are too recent to serve as a basis for prediction, particularly with our present inadequate understanding of the global mechanisms of atmospheric circulation. The latest Sahelian drought was far from unprecedented, even in the relatively short historical record, and it cannot alone form evidence of a change of climate. At the same time, it would be unwise to rule out the possibility of change, and the consequences of change should be looked at, particularly in areas of strong rainfall gradient such as the Sahel. It would certainly mean that droughts would become more frequent and more severe, and that plans for land management should take into account the possibility of an even more rigorous climate in the future.

Man made climatic change

Linked with this postulated swing to increased aridity is the suggestion that man himself may have contributed to such changes through modifications in the energy exchange that have followed man's degradation of desert ecosystems. These modifications include an increase of dust in the upper atmosphere, noted particularly in association with the recent African and Asian droughts, and the increased reflection of solar energy from denuded dryland surfaces. It has been argued that these factors have contributed to a lowering of temperatures above dryland surfaces and diminished convection in the atmosphere, with an ensuing reduction in the frequency of rainstorms.

At this time, however, the direction in which these factors move remains in doubt. It may be realistic to grant that man has accentuated climatic stresses but it is most unlikely that the factors named have been prime causes of any general deterioration of dryland climates, which are, after all expressions of fundamental patterns in the circulation of the atmosphere. It is also probable that the direct physical consequences of the man-made changes, such as the adverse effects of surface denudation on the local water balance, are many times more important than any indirect climatic effects.

Climatic fluctuation contribute to desertification

Climatic boundaries in the drylands are also subject to shorter-term shifts, corresponding to sequences of lean years and fat years. In general, the drier the climate, the greater the rainfall variability and the higher the drought risk. Such fluctuations are expressed in expansions and contractions of the dryland belts, such that a semiarid region may experience arid conditions at one time and subhumid conditions at another.

These fluctuations, although not so regular as to be predictable, may nevertheless be classed as short-period, say two to four years, which merely introduce periodic stress into livelihood systems, and those of greater amplitude and duration which lead to significant changes in the patterns and structure of land use, such as extensions of cultivation or large build-ups in stock numbers. These changes can

result in a potential imbalance which may not be promptly adjusted when drought inevitably follows. It is at such times, when dryland ecosystems are stretched to the limit of their resilience by water deficiency, that the pressure of unbalanced land use can be disastrous. Recovery from such degradation will be slow. If land use pressures continue unabated recovery may be partial only, to a lower plane of productivity than formerly. Desertification will then have occurred.

Fragility of dryland ecosystems

Desertification may proceed relatively rapidly in dryland ecosystems because of their fragility under land-use pressure. They generally support only scanty amounts of plant and animal life, and because life is thinly spread, the soils are poor in organic nutrients, usually found only in the thin topmost layers. Thinly buffered by a skimpy plant cover, the soil is exposed to erosion which removes nutrients and results in structural deterioration. Lack of leaching and strong evaporation leave unwanted salts on the surface.

All this creates ecosystems delicately balanced on the furthest edge of biological possibility, particularly during drought. Their necessary adaptation to water stress restricts dryland ecosystems to a limited range of response and hampers their flexibility. Life forms are limited in variety and highly specialized, and when one species is eliminated there may be nothing to replace it. Such systems have little slack as it were, and their recuperative processes are slow. They are especially vulnerable to the impact of land use.

Misuse of drylands

Any use of drylands that does not take account of this fragility and of their extreme variability in biological production will constitute misuse. This variability demands a flexibility and promptness to react which desert livelihood systems have rarely shown, a response which is, indeed, very difficult to carry out in the absence of long-range weather forecasting.

The situation is complicated by overoptimistic assessments, often made on the basis of remembered best years, of the potential of the land for sustained production. Excess optimism often results from pressures to which arid-land agriculturalists are increasingly subjected - from population growth, from distant commercial markets, from their own rising expectations.

Frequently, too, there is a failure to appreciate the relation between these particular environments and their use. Herdsmen, for example, tend to see their ultimate resource, their wealth, in their breeding flocks or herds rather than in the land and vegetation that support them.

Pastoralists often herd several kinds of animals, each capable of profiting from different portions of the ecosystem, just as dryland cultivators have tended to plant a mixed crop. Out of the push towards maximum output and toward the environmental limits of land use, the

current trend is toward specialization, which fails to spread the risk and lessens flexibility. This is particularly so under the impact of commercial ranching and farming. Flexibility may also be hindered by inequitable systems of land ownership and land tenure.

Techniques such as deep ploughing or clean tilling have on occasion been introduced into dryland agriculture even though they are unsuitable there. Projects have sometimes been undertaken without full regard for the tenuous equilibrium of these ecosystems. For instance, deep tube wells introduced into pastoral areas have indeed improved the availability of water but at the same time have had the effect of increasing herd size while decreasing herd mobility, leading to local overgrazing and excessive trampling of the soil. Technological changes can give rise to desertification through increased, even excessive demands on limited natural resources.

The misuse of arid lands is by no means restricted to inappropriate agricultural practices. Modern man is threading the arid lands with roads and highways; he is exploring them for mineral resources, opening mines, sinking oil wells, constructing pipelines and canals, establishing factories, and building cities in them. Increasingly, he is intruding into arid lands for purposes of health and recreation. These activities are seldom undertaken with full understanding of or proper regard for the delicate natural balances that prevail there. Many such activities have been made possible by advanced technology, but it is this same ever-growing technological capacity that so enhances man's ability to disrupt and damage a sensitive environment.

Rapidity of feed-backs in dryland situations

All such activities must take full account of the fact that the drylands reach to the edge of biological possibility. Generally impoverished soils, scanty amounts of life and tenuous biological linkages among the life forms that do exist there make the drylands critical areas, their condition becoming ever more critical as aridity increases. In such situations, very small changes can trigger profound effects. Where the equilibrium is delicate, even a small change in one component will radiate effects through the entire ecosystem. Drylands are extremely sensitive to tiny changes in their water and energy balances. Changes brought on by seemingly minor events can follow with startling rapidity, sometimes sufficient to throw the system beyond the critical threshold whence recovery will not naturally occur.

It might be objected that the drylands, with their highly variable rainfall and periodic drought, are continually subjected to extreme conditions, and the question arises, how do their life forms persist at all? It has been shown how plant life in arid lands is naturally adapted to such circumstances, Animals in arid lands are characterized by similar adaptations and often by great mobility. When rain returns after a drought, the water store is replenished in the soil, the

vegetation recovers and the animals wander back. The extent and rate of restoration are a measure of the resilience of the ecosystems. All drylands exhibit ecosystems with natural resilience, although the process of natural restoration is sometimes very slow. If left alone, they will almost always return to what they were.

Full restoration will not take place if an area is undergoing climatic change in the direction of greater aridity. But climatic change takes place at a tempo which allows time for human adaptation.

Desertification: a product of the interaction between man and a difficult environment

More commonly, failure in resilience arises from severe disturbance and such disturbances, in the present world, are almost always the work of man. Human activities may have less disastrous impact in more flexible environments, where a greater richness of land and life forms aids the process of restoration. Lands on the margin of life lack these resources. Disturbances there can easily become permanently destructive, as evidenced by desertification.

If man is the chief instrument of desertification, the process should not be viewed exclusively from the human side. Desertification results from the interaction between man and a difficult and changing environment. It occurs when man penetrates such environments and acts there without an understanding of or proper regard for their sensitivities and limitations.

IV

Desertification in Action

Desertification and livelihood systems

The interaction between man and a difficult environment - since that is the main engine of desertification - can well be examined in terms of what man does in the drylands, how he wrests a living from this environment, as difficult as it is.

Dryland agriculture takes three main forms; pastoralism or the herding of livestock, rain-fed agriculture, and irrigation agriculture. All these systems have evolved strategies and traditional skills to cope with the stresses and risks imposed by dryland environments. Such tested practices should not be lightly dismissed; indeed, they should be regarded as a basis for further development.

Yet it cannot be said that any such practices have been so self-regulating or so far-seeing that they have incurred no cost to the environment. Desertification has accompanied all of them although its effects may have been less destructive in the past. The accelerated desertification of recent years may in part be attributed to breakdowns in traditional practices. The old ways have come under intense pressures which have eroded ancient social, economic and political constraints. Such pressures have come from population growth, the integration of the drylands into money economies, aspirations toward higher standards of living, the introduction of technological innovations and the incorporation of dryland agriculture into often remote commercial systems, into marketing systems where prices fluctuate.

Dryland pastoral systems

General aspects

The extensive pastoral systems characteristic of the drylands use grazing or browsing animals to harvest a thin crop of natural vegetation.

In semi-arid lands, stock raising is increasingly integrated with crop production. In arid regions, beyond the reach of the farm, pastoralism is dominant, and here the herdsman is subject to the extremes of climatic hazard.

Herdsmen have found many ways of coping with the climatic stress that typifies arid zones. Ordinarily, they spread their stock thinly over large areas so that grazing pressure is lightened and they can take advantage of the patchwork ecosystems of arid lands. They are highly mobile, often traversing great distances to reach seasonal pastures.

They usually employ some measures to modify the ecosystems in which they function. They will limit the size of their herds, if necessary by selling off surplus animals. They will exercise some control of pastures by deferred or rotational grazing or by spelling certain rangelands to allow them to accumulate moisture over several years. They will develop additional watering points, extending the area and duration of grazing and diluting the pressure on older pastures. They sometimes burn pastures to facilitate the growth of more palatable plants. Sometimes, too, they will provide supplementary feed by cutting hay or growing forage crops under irrigation.

Some herdsmen have access to alternative sources of income. They might engage in hunting and gathering, or perhaps commerce, a natural adjunct to their mobility. They sometimes develop handicraft industries.

Pastoral systems can range from traditional subsistence systems, often nomadic, through more sedentary systems closely linked with cropping, to the great commercial ranches which mainly serve as exporters from the arid zones. All tend to have links with the outside where the chief markets are to be found - for hides, wool and stock on the hoof. In the more commercial pastoral systems, stock will be bred in the arid zones and fattened in areas closer to the market. As breeding areas, arid zones have certain advantages, such as freedom from disease, long outdoor range periods and high protein levels in pastures.

For all its hard-won skills, pastoralism frequently betrays failures of perspective. Identification of the breeding stock, rather than the land and its vegetation, as the ultimate resource leads to a poor understanding of the ecology of the plant communities on which the stock feed. Comparatively little attention may be paid to the performance of pastures under stress, to the requirements for successful germination or to the impact of selective grazing on the whole plant community.

Nor do pastoralists always appreciate the difference between average stocking rates and what happens where animals cluster together, as around watering points or settlements. Concentrated grazing and excessive trampling will focus degradation on such spots.

Pastoralist systems are generally afflicted with what might be called a time-lag problem. Increased stock numbers built up in favourable years persist into drought, and conversely, herds reduced by dry years will confront the return of better grazing with numbers too scanty to take full advantage of it. The kind of flexibility that would make a fully opportunistic use of the land is difficult to introduce into stable pastoral systems.

Such misapprehensions and difficulties mean that pastoral lands exhibit a full range of desertification, advanced where pressures on the land are concentrated, less in the more remote and least attractive sections.

When deterioration comes to grazing land, it is particularly important to observe its first stages in vegetation, not only because plants are the basic grazing resource but also because of the part they play in the stability of dryland ecosystem.

First to be consumed are the more desirable plant species leaving the terrain to less desirable invaders. During drought stress when they constitute the only feed, valuable, soil-holding perennials can be grazed to extinction. Invasions by xerophytes are a sign of increasing salinization. The exposure of ever more bare ground diminishes the response of green feed following the rain and hinders the return of desired perennials. Stripped earth becomes particularly noticeable around concentration points, such as watering places, where trampling is severe.

Nomadic pastoralism

Stock-herding nomads have found ways of using land too arid for any other agricultural purpose. With a diet obtained from their herds and supplemented by food gathering, wandering pastoralists have achieved standards of health and nutrition often superior to their more sedentary neighbours.

It is, of course, mobility that provides the nomad with his principal weapon against a harsh environment. His wanderings may be continuous, or he may move back and forth between fixed seasonal pastures. Flocks and herds are generally owned by families, but other resources - pasture, watering places, fuel - are often communal and their use regulated by custom.

Almost all nomadic pastoralists have mutually beneficial relationships with the farmers on their periphery. Such links may include nomadic ownership of cropland, provision of seasonal labour to oasis settlements and the right to graze stubble in exchange for the manure naturally dropped by grazing animals.

If the resiliency of nomadic pastoralism resides principally in mobility, which spreads pressure on the land and dilutes risk, the system also contains other important adjustments. Nomads often herd a variety of animals, each species capable of exploiting a different portion of these mixed environments. They may do some rain-fed cropping on the edge of the migratory range. As stated, they may supplement their diet by hunting and gathering, and they may have beneficial relations with adjacent farmers. As an adjunct to mobility, they may play a role in transportation in desert areas and its associated commerce. They may earn income through handicrafts. Finally, some of their numbers may emigrate to outside employment, whence they remit funds home.

Yet for all its resilience, pastoral nomadism has not avoided all damage to its environment. If its impact has been less in the past, there is still evidence, as in the Bible and elsewhere, that damage has occurred in ancient as well as modern times.

Increasingly over the past fifty to one hundred years, pastoral nomadism has found itself at bay. The political status of the nomads had declined, and with it, their control of grazing rights, their relations vis-à-vis adjacent crop-based systems, and their role in desert transport and commerce. Their essential mobility has come into disfavour for political and administrative reasons, and has proved to be an obstacle in providing them with education, health care and other essential social services.

In addition, imbalances have arisen in systems of pastoral nomadism which have heightened their potential for desertification. Among nomads, too, modern health care has reduced mortality and given rise to population growth even if at a lesser rate than among their neighbours. Population growth has been a factor, together with improved veterinary care, leading to an explosion in livestock numbers. Expansion of the systems, together with breakdowns in traditional authority, have affected rational management and make improvements difficult within the existing structure. Traditional subsistence activities have increasingly

fallen into a neglect hastened by the use of money. Sedentarization, whether voluntary or enforced, has resulted in severe degradation around permanent settlements where former nomads continue to herd livestock. Technology has been introduced without concern for all factors in the environment. The use of off-the-road vehicles for hunting or fuel gathering has been particularly destructive. The provision of large central watering points, out of harmony with traditional migration patterns, have led to unusual concentrations of stock and extreme local degradation. Grazing ranges have shrunk because of invasion by crop-based systems or political restrictions on the movements of animals.

That nomadic pastoralism is in trouble is evident in increasing desertification associated with such systems. Pastures have widely deteriorated, showing increased surface instability especially in their more vulnerable elements, such as once-vegetated sand dunes. Advanced physical degradation around watering points, stalls and settlements and along paths of stock movement is marked by accelerated wind erosion and local dune encroachment. Even though limits are imposed more by lack of fodder than lack of water, an over-exploitation of groundwater reserves has lowered watertables and affected water quality. Pastures show themselves to be increasingly vulnerable to drought with all that this implies - destruction of livestock, enforced abandonment of grazing lands, deterioration in the diet and health of the people involved. Increasingly, former nomads are migrating out of the rangelands, and there is some suspicion that the migrants are largely the young and the more innovative.

Traditional more sedentary pastoral systems

Sedentary pastoralism is usually supported by rain-fed cropping. Evidence of stock losses during the recent drought in Somalia suggests that these systems are less resilient than nomadic pastoralism.

Because it is sedentary, this style of pastoralism usually encourages localized degradation wherever the livestock tend to concentrate. Desertification also arises from the cropping elements in these systems, usually practiced on the most marginal farm land, where the herdsman-farmer may constitute an impoverished part of a commercial system. The farming, a secondary activity, may suffer from a shortage of labour, sometimes due to out-migration.

Commercial ranching systems

Commercial ranching tends to specialize in one kind of animal or breed, selected usually for marketing reasons rather than because the animal is physiologically efficient in converting the local dryland vegetation into need.

Such systems compensate for environmental risk and low productivity by adopting very low stocking rates (lower than those of nomadic pastoralists, for example). They are rarely sited in the most arid, remote or infertile regions. Yet since land is a low-cost item, commercial ranches tend to be large units put together out of the vagaries of competitive stress.

Such ranches tend to minimize labour costs, especially in high-wage economies. Stock is set to graze in large, fenced enclosures and controlled with a minimum of handling, although winter stalling and feeding may be required in temperate to cold drylands. The

comparatively small labour force is highly mobile, whether on horseback, driving off-the-road vehicles or piloting aircraft. For special tasks, such as such as fencing or shearing, or at times of seasonal demand, contract labour will often be employed.

These systems have inherent weaknesses, one of them stemming from animal specialization, which increases environmental risk and commercial vulnerability and results in inefficient use of the pasture complex.

Laxity in grazing control is often combined in commercial ranching with ignorance of the impact of grazing on pastures. Despite the expansion of extension services, comparatively little attention may be paid to the relative performance of pasture species under grazing stress and to the requirements of soil and plant life as they relate to grazing management - what is needed, for example, for the successful germination of desirable perennials. Since land and vegetation are the low-cost elements, they are not always viewed as the ultimate resource base, the livestock itself being so regarded.

Commercial ranching is dependent on external markets whose forces may or may not be in harmony with wise stocking policies and practices as called for by the local environment. The tendency to maximize profits can readily lead to poor ecological management and overstocking within short-term perspectives. Such ranching is often controlled by corporate managers or absentee landlords who tend to be less immediately concerned with the state of the range.

These systems enhance their vulnerability by ignoring subsistance elements. Food and supplies are purchased at the market.

The growth of large units and the labour economies imposed on them lead to a progressive decline in the populations they support with consequent out-migration, particularly of the young and landless. The populations of ranching areas are generally on the decrease, with an accompanying decline in secondary service centres.

Capitalization and technical improvements tend to buffer commercial ranching against the immediate consequences of overgrazing, and high prices for its products will yield cash returns which may further delay a response. Since a determination of range trends is difficult in any case, delay can lead to irreversible deterioration of pasture long before economic collapse occurs or even before the situation is truly appreciated.

The weaknesses of commercial ranching have their inevitable sequence in desertification. Poor grazing control results in deterioration of pastures which can be severe at the most vulnerable spots and around places where livestock congregate and further the process by trampling the soil.

Unlike more traditional systems, commercial ranching makes large-scale use of heavy machinery for construction and road building. Such machinery disturbs the environment, producing localized degradation.

The greater capacity for ecological manipulation in these technically advanced systems may have drastic feedback consequences. For example, the control of brush fires has resulted in invasions by undesirable scrub in such places as southern Australia and the south-western United States.

Commercial ranching tends, as time passes, to deplete the soil of nutrients and organic matter. These elements can conveniently be returned to the soil wherever winter stall feeding is practised. Even if it might seem economically impractical to spread barn and feedlot manure on rangelands, such a practice may be an essential health measure if cities are nearby or water supplies threatened with contamination.

Depopulation might be listed as a desertification phenomenon characteristic of commercial ranching, even though it may be caused by market forces working independently from land degradation.

Rainfed cropping systems

Rainfed agricultural systems, referred to in general as "dry farming", are typical of the semi-arid lands, which include those regions in which agriculture was first practised by man.

Rainfall in such regions, although generally more abundant than in lands dominated by pastoralism, is still limited. Farming is possible there only through the adoption of special techniques whose primary objective is the collection, storage, protection and utilization of every drop of water. Drought-resistant crops are selected for planting, notably the cereals - wheat, barley, rye, sorghum - so typical of dry farming.

Special techniques and careful crop selection have carried dry farming to the climatic limits set by rainfall - its amount, seasonal incidence and variability - and by the length of the growing season, as fixed by the duration of rainfall and, in high latitudes, by light and temperature.

This push toward the climatic limit has carried rainfed agriculture deep into areas that were once exclusively pastoral, displacing the herdsmen and pushing them ever further into drier lands. Although the productivity of dry farming is low when compared with irrigated agriculture, its returns are usually much higher than pastoral yields.

Dry farming compensates for climatic risks by producing crops of high quality, hard wheats for instance, which can command good prices. The semi-arid regions are free from disease, notably rust. They provide extensive stretches of sparsely settled land suitable for tillage by large-scale mechanized agriculture. The cereal crops produced are easily handled, transported and stored.

Clearing for agriculture involves a much more drastic transformation of natural ecosystems than does pastoralism. Dry farming exposes and disturbs the soil, increasing the risk of erosion. Some dry farming techniques enhance this risk.

Shallow ploughing, for example, or loosening of the soil in the preparation of seedbeds can set the stage for erosion, just as does tillage of the subsoil to return organic matter to depth and to facilitate root penetration and moisture availability in soils that tend to form lime or clay pans. Bare-fallowing is also a common practice. Here the land is left stripped of vegetation to allow the infiltration of an additional season's rainfall and to minimize losses through transpiration. Such fields are also fine-tilled to prevent capillary loss of moisture and to promote the aerobic nitrification of organic compounds.

Many of these systems spread across open plains which are already subject to wind erosion. The wind picks up the silty soils, creating a dust nuisance and sometimes dust storms. Sand drift and dune formation are common on the sandier alluvial soils near old river channels. All such effects are enhanced by the removal of trees and high-standing vegetation over extensive areas.

Dry farming tends to specialize in both crops and techniques, and it does so at the expense of mixed farming, which would include crop rotations involving legumes and the raising of animals. This results in an undue removal of organic material, transported away in the off-farm sale of grain and in the burning of straw and litter after harvesting with combines. Decades of producing one specialized crop have resulted in the depletion and breakdown of many semi-arid soils that once possessed excellent structure and fertility. When this happens, yields decline and erosion increases especially on finer textured soils such as those lying on wind-blown parent material (loess).

These systems support much denser and more settled populations than do pastoral systems. Man and his works therefore exert a much stronger impact in them. Many such systems have been worked for millenia and provide a history of land use and of land deterioration extending over thousands of years.

Regional Problems in rainfed cropping

Rainfed cropping systems comprise several types as determined by climate and other environmental conditions. Each is marked by its characteristic crops, technology and cultural setting. Each is vulnerable to desertification, which takes on distinctive forms in each setting and calls on distinctive measures to combat it.

The Mediterranean region

The Mediterranean is a semi-arid region with winter cyclonic rainfall and warm to subtropical temperature régimes. It is a hilly region with degradable limestone soils in which cultivation has been extended into areas of very low rainfall (locally less than 200mm annually). Winter cereals may alternate with summer crops. Farming is often combined with animal husbandry, especially of sheep and goats. Tree farming is particularly important. Connexions between rainfed and irrigated cropping are particularly close in the Mediterranean, with the former also deeply involved in water management, as in the terracing of slopes whose upkeep requires not only much labour but social stability as well.

The Mediterranean has a long history of land use by fairly dense populations. Its history is also one of cities, many of them large and important. Man has thus had a profound impact on the Mediterranean ecosystems, which provide, in fact, the longest historical record of desertification. Land degradation appears to have been associated with the spread of sedentary agriculture and its related settlements. In some parts of the Mediterranean, desertification has reached advanced stages.

It appears there in the deforestation of once-wooded uplands. Forests have given way to dwarf, leather-leaved dryland shrubs, or to bare earth, with soil sometimes stripped completely from slopes to uncover calcareous crusts or naked rock.

This stripping of upslope watersheds has severely damaged downslope water régimes. In many places, runoff has become ephemeral and spasmodic, sometimes giving rise to catastrophic flooding in the lowlands and to increased deposition of silt in valley bottoms. Siltation, which was a problem in ancient days (as among the Nabateans of the Negev) continues to pose a major threat, as for example to the useful life of large reservoirs in modern water-control schemes.

The region shows broad deterioration in groundwater reserves accompanied by a lowering of groundwater tables and a decline in water quality. Some areas, such as the coastal plain of Israel, have suffered invasions of seawater.

Cultivated footslopes often show marked gullying, particularly where cultivation has been unwisely extended over the past 50 years because of rising population pressure. The loss of soil has been considerable and with it, the loss of potentially cultivable land.

Despite growing populations, labour shortages have developed as a result of heavy migration to cities and settlements, and water management has been affected. Terraces and qanat systems have suffered from lack of proper maintenance.

The removal of trees and shrubs has accelerated wind erosion of light soils, stripping them of nutrients. In many places, as in southern Tunisia, wind erosion has led to the formation of coppice dunes and made the land unsuitable for cultivation.

Some lowlands soils, particularly in basins of interior drainage, have suffered from the spread of salinization.

Mediterranean-type regions

Other areas with a Mediterranean-type semi-arid climate are distributed around the world. Such regions include, for example, semi-arid portions of southern Australia, southwestern Cape Province in South Africa and the Colombia Plateau in the northwest of the United States.

These are typically regions of highly mechanized agriculture producing cereals for export. Their devotion to monoculture has resulted in a lack of leguminous rotation crops and a virtual absence of

animal husbandry, thus limiting the return of organic matter to the soil. This, associated with the export of the crop and the removal or burning of the vegetable litter produced by mechanical harvesting, has depleted the soil of mineral and organic nutrients. Light-textured gray-brown or black-earth soils, depleted of nutrients, have increasingly been subject to wind erosion. Deterioration following continuous cropping was reflected in the inter-war years by falling yields.

Depending on the setting, desertification in various forms has made its appearance in all Mediterranean-type regions.

Extensive gullying of slopes, as in Cape Province and the Colombia Plateau, has become a particular handicap to mechanized agriculture.

Tilled but unvegetated surfaces that occur where dead-fallowing is practised have been extensively subject to general sheet erosion by water.

The almost complete clearance of vegetation associated with large-scale mechanized agriculture has resulted in wind erosion of light soils and once-stabilized dunes, causing sand drift and the mobilization of fresh dunes as in, for example, the Mallee region of South Australia.

The clearance of deep-rooted shrubs and their substitution by crops or fallow has reduced transpiration in favour of evaporation and increased runoff from cleared slopes. This has altered the water balance in valley soils and brought on salinization. Such effects are particularly noticeable in areas of sluggish natural drainage, as in northern Victoria and southwestern Western Australia where saline groundwater has come to the surface with increased effluent seepage from lower slopes.

Subtropical to warm-temperate regions

In subtropical to warm-temperate regions of dry farming, transitional rainfall régimes are characterized by winter and summer rainfall. Under such conditions, winter cereals can be combined with a variety of spring-sown crops, such as cotton in the southwest of the United States or sugarbeet and sunflower between the Ukraine and the Caspian Sea, resulting in a favourable mixed agriculture with a more continuous cover. Such farming systems are generally young, having been established over the past two centuries in such rich soils as the black earths of the southern USSR.

In these systems, soil depletion with falling yields has only recently become evident. The application of mineral fertilizers and the replacement of organic losses are increasingly required.

The plains topography of these regions, characterized by an absence of trees, has promoted desertification through wind erosion.

Erosion, together with reduced yields, has also been encouraged by a moderate salinization and alkanization, arising from limited leaching, that have affected the drier parts of these regions.

Cool temperature semi-arid regions

Cool-temperature semi-arid regions typically have rain in spring and early summer. They include, for example, a broad strip from southern Siberia into Manchuria and the dry prairies of Canada, where exposed surfaces, severe winter temperatures and sunlight limitations result in a short growing season restricted to spring cereals and great difficulty in introducing cover crops other than grass. Under such conditions, animal husbandry is also very difficult.

Wind erosion is the characteristic form of desertification in such regions of open plains. Most affected during the dry winters or late summer are the light-textured soils often lying on a carbonate or hardpan layer.

Tropical semi-arid summer monsoon regions

Tropical semi-arid summer monsoon regions are typified by the Sudanian belt, with its 300mm to 600mm annual rainfall, to the south of the African Sahel. They also include the margin of the Rajasthan Desert in northwest India and parts of northeastern Brazil. They tend to grade into subhumid savannas, lands which must also be considered at risk.

In these regions, open savanna woodland is cleared, usually by burning to provide a seedbed, although clearance is not complete and many large trees may be left standing. The pattern is generally that of shifting agriculture. Four to five years of continuous cropping are followed by abandonment, when successional regrowth may be harvested, gum arabic for example, or grazed by cattle, with the growth of grass encouraged by burning.

This is mainly subsistence farming by peasants, who grow grain crops such as sorghum or millet. The warm climate may allow a second crop, such as groundnuts or cotton in Africa, increasingly grown for cash. Adjacent pastoral peoples may introduce an element of animal husbandry into these systems, with the rights to graze on stubble obtained through various types of exchange or through cash payments.

During periods of above-average rainfall, these systems have tended to encroach on neighbouring animal-based systems because of the pressures of population growth or for the extension of cash cropping. Such encroachments are successful until the rains fail, as they inevitably do. The severe imbalances which then appear can act as a major accelerator of desertification, as they did in the recent Sahelian drought, affecting not only the farmland itself but also the pastoral areas which farming had invaded.

Desertification in these systems often appears as a marked decline in fertility following the loss of organic matter and a deterioration in the structure of the typical red, sandy subtropical soils. This often comes about because population pressures and a resulting land hunger act to speed up the agricultural cycle, bringing the farmer back to the same piece of land in fifteen years, say, instead of twenty. The rise of cash cropping accelerates the removal from the soil of mineral and organic nutrients. The introduction of equipment unsuited to the particular conditions of these regions has resulted in deeper tillage and aeration and a consequent pulverization of the soil.

As fertility declines, crop yields are less, and adverse impacts become self-accelerating. To make up the difference, the land is worked even more intensively.

Rainfall in these regions, while localized, is often intense, causing pluvial erosion of cultivated surfaces. Soil surfaces become puddled and soil structure severely damaged. The dry spells that alternate with the onset of rains bake a crust on the surface, hindering the germination and development of seedlings.

During the dry winters, wind erosion lifts clouds of dust from these lands, sometimes transporting it over enormous distances. Soils in the Caribbean islands have been enriched by what has been lost from distant northern Africa.

Irrigated cropping systems

Irrigation provides the main basis for agriculture in arid regions and serves as a vital supplement to crop production in semi-arid regions. About 13 per cent of the world's cultivated lands are irrigated. Although not all of these 200 million hectares are located in drylands, still that is where the impact of irrigation is greatest.

World food production must increase if present nutritional deficits are to be corrected and an expanding world population adequately nourished. A 30 per cent increase in cereal production alone has been projected as essential between 1970 and 1985. Some of this increase will have to be obtained by further development of irrigation.

Compared with rainfed agriculture, irrigation can lead to a six-fold increase in yields of cereals and a four-to-five-fold increase in root crops. The importance of irrigation to agricultural development is revealed by the fact that the irrigated harvest area in developing countries is expanding at a rate of 2.9 per cent per year compared with an annual expansion of 0.7 per cent for rainfed crops. Irrigation in arid lands can therefore be expected to play a critical role in satisfying the world's food requirements. Measures to combat desertification in such systems are accordingly of the utmost urgency.

Its remarkable productivity is one aspect of the importance of irrigation in arid lands. The productivity of rainfed cropping as carried out in areas with less than 250-400mm of annual rainfall, is much lower because of this limitation in available moisture. Not only does annual irrigation increase yields but it also allows the replacement of fallowing systems by annual cropping.

The increased stability of crop systems with the removal of drought risk and uncertainty is another advantage of irrigation.

Animal-based systems are made more stable and efficient when they are carried out adjacent to irrigation, which can provide them with forage crops as supplementary feed and can store reserves against the threat of drought.

Irrigation increases the efficiency of cropping systems. For instance, the application of fertilizer and the planting of higher-yield crop varieties are greatly facilitated wherever productivity is not limited by the availability of water.

Irrigation diminishes the risk of desertification in cropping systems. The planting of trees and a more consistent vegetation cover replace fallowing and the open and exposed landscapes characteristic of other dryland systems. Irrigation provides water which can be used to reclaim desert lands, whether by supporting a plant cover or by the leaching of salinized soils.

As rich producers of cash crops, irrigation systems serve as important economic resources for arid lands. They provide a basis for dense settlement and its related social amenities in regions that once supported only sparse populations. As such, irrigated lands can be used for the resettlement programmes that desertification elsewhere sometimes makes necessary.

It is not merely because they are short of rainfall that arid lands are particularly suited to irrigation. Situated as many arid regions are in the cloudless subtropical zones of atmospheric subsidence, they are favoured with long hours of sunshine. This makes irrigated lands suitable for multicropping and the growing of early maturing, warmth-demanding crops that command high prices in regions that are not so sunny. Algeria or Israel, for instance, produce winter and spring flowers and tropical fruits that are shipped off for sale in Europe.

Again, under conditions of low rainfall, carefully irrigated soils suffer only limited leaching of fertilizers and nitrogen. Plants grown in low atmospheric humidity are relatively free of diseases, such as rust in cereals, that flourish in moister conditions.

Arid lands are rich in terrain and soils, such as sloping piedmont plains of interior, well-drained river systems, that are remarkably productive when water is brought to them. Many such places still remain to be exploited by intensive cropping.

Irrigation, however, is often a costly, technically complex procedure that requires skillful management and sound experience if its full advantages are to be realized. Furthermore, it gives rise to changes in all the major ecosystem régimes - soil, water and atmosphere - that may introduce unwanted effects leading to desertification unless appropriate precautions are incorporated into the system.

A failure to apply efficient principles of water management will lead to water wastage and hence loss of productivity. Such wastage can occur at any point in the system - through seepage and evaporation during storage, conveyance or distribution or as a result of bad timing in water application, of over-watering or poor techniques of field application.

Poor application can result in waterlogging of soils, which reduces productivity through inadequate aeration and its associated salinity, eventually leading to the loss of irrigated lands. This is a problem locally associated with low-lying tracts and areas of heavy soils. Waterlogging is more generally related to the artificial raising of water tables because of seepage, inadequate drainage and over-watering. It is a major factor in the salinization of irrigated soils.

When soils are inadequately leached of the minerals contained in irrigation water, then excess evaporation and transpiration will result in salinization and alkalization of soils. Where drainage is inadequate, whether natural or artificial, salts accumulate. The process commonly begins where natural seepage occurs, as along the margins of irrigated land commanded by higher ground, in an irrigated terrace for instance, or where there is seepage from a network of channels. It spreads where irrigation has been carried into areas of unsuitable soil, such as alkaline clays, or into unsuitable terrain, such as flood plain sumps or the higher parts of poorly levelled lands. In such situations, when leaching is inadequate, salt crystals will appear on the surface.

Salinization and alkalization become general problems wherever artificially raised water tables, associated with waterlogging, capillary rise or pollution from salinized outflow, prevent the proper leaching of salts. Salinization also occurs when the irrigation water is too salty or when there is not enough of it to leach the salts from the soils. It has been estimated that half of all irrigated soils in arid lands are affected by salinization to some degree. The eventual result can be found in lowered yields, restrictions in the choice of crops and the final loss of irrigable lands which can only be reclaimed at great expense. In monetary terms, no type of desertification is more costly to man.

Alkalization, improper watering, inappropriate tillage of moist soils and the leaching of soils containing gypsum can lead to a deterioration of soil structure and compaction. This results in poor aeration, reduced transmission of irrigation water and finally to lowered yields. Suffusion of the soil with water that fails to drain properly can lead to catastrophic subsidence of the ground. Further irrigation then becomes impossible without expensive relevelling.

Recycled irrigation water may become progressively more salty, aggravating a tendency toward salinization. Excessive watering can remove essential nitrogen from the soil.

Since irrigation provides a basis for intensive agriculture in arid lands and for dense settlements there, often including people who lack traditional experience in agricultural methods and their associated societies, the development of irrigated agriculture often brings social problems to arid lands. These problems are linked to profound modifications in local or adjacent ecosystems, notably soil and water régimes, involved in the development of irrigation.

Irrigation calls for particular skills in the application of water and the tillage of watered soils if its great potential for increased productivity is to be developed and sustained. The efficiency of irrigation schemes rests in the last analysis on the individual cultivator. When cultivators lack the appropriate agricultural experience, irrigation systems and the lands they water can suffer great damage.

Potentially beneficial to health through improved nutrition and water supplies, irrigation can also give rise to serious health problems. It can increase the risk of water-borne, directly transmitted diseases such as bilharzia, malaria and typhoid fever. Malaria has been identified as a problem in the early irrigation civilizations of the Nile and the Tigris-Euphrates. The transmission of disease is facilitated by water mismanagement which results in the formation of stagnant pools and by a lack of hygiene and sanitation under conditions of dense settlement. Chronic ill health gives rise to losses from labour inefficiency.

Laws and traditions can present obstacles to efficient irrigation by establishing curious restrictions on water use, illogical subdivisions of the land or contractual limitations on tenant activities.

Irrigation gives birth to cities in arid lands and to the social stresses that arise when peoples of diverse backgrounds come into contact with one another in a new social and economic environment. Dense settlements have a profound impact on the surrounding desert environment, and this impact can be very damaging where populations have no tradition of close settlement.

Irrigation systems can be based on surface waters or on ground water. Each type brings with it its own characteristic problems.

Systems involving the use of surface waters range from flood farming or flood-recession agriculture in floodplains, through annual basin irrigation using flood banks, to perennial irrigation using manmade storage reservoirs and canals. Systems of the last type, based on rivers flowing through or on large upland sources of runoff, support the largest populations and the most intensive agricultural production in the arid lands. Such systems call for advanced, large-scale management.

Devegetation, surface deterioration or gullying due to overgrazing or the extension of croplands, the breakdown of works such as terracing intended to control runoff, all give rise to problems in the management of surface water. All such deterioration promotes increasingly spasmodic and violent local flooding which complicates water management and gives rise to flood damage and siltation in storage reservoirs and on irrigated lands. It may also lead to a decline in water quality through the exposure of saline soil layers.

Irregularity of water supplies is a frequent problem in such systems. Studies indicate that a given quantity of water is two to three times as effective if applied regularly and consistently rather than via a one-time flooding.

Systems employing surface waters are confronted with problems of storage. Reservoir capacity can be lost to siltation in erodible desert watersheds. Seepage can involve the loss or salinization of irrigation water. Evaporation, too, can enhance salinity.

Such systems are also confronted with problems relating to water conveyance. Water losses in travel, averaging fifty per cent, arise from seepage and evaporation in networks of channels. Such problems can become acute in very large systems containing long distribution channels.

Irrigation water can become increasingly saline as it is recycled in surface runoff or subsurface flow, when it becomes contaminated by saline soils, particularly where discharge declines as the water moves down valleys.

When surface-water systems are adjacent to large rivers, they are subject to a risk of flooding. When they are located in large desert river basins, they always involve problems of water resources and water rights at local, regional and international levels.

Systems involving the use of groundwater suffer from their own distinctive set of problems. These are usually smaller schemes than the often elaborate systems that draw on surface water. All told, they probably amount to less than 10 per cent of the extent of surface-water systems, but they are particularly important within oasis settings, including those within extreme deserts. Such systems sometimes exploit shallow subsurface water by means of hand-dug wells. In other settings, they go deeper and require the use of pumps. They may tap artesian supplies or they may "mine" non-renewable deep-water sources.

Groundwater is commonly more saline than surface water. Limitations in supplies and difficulties in terrain may present great difficulties in obtaining effective leaching and drainage. Salinization of soils, often working through the mechanisms described in connexion with surface-water use, is a frequent problem in groundwater systems.

Problems also arise from over-exploitation of limited supplies. As water is used up, shallow sources may be abandoned, and pumping becomes increasingly expensive as draw-down affects marginal wells. Less favourably sited wells may become so drained that marginal lands will be abandoned. Heavily exploited water may suffer from an increasing accumulation of salts through recharge by salinized water, thus aggravating the problem of soil salinization. Seawater may encroach on aquifers that are intensely exploited in coastal drylands.

Problems can arise in groundwater systems due to the raising of the watertable as supplies are brought up from depth. When drainage is hindered, this can lead to the pollution of aquifers by saline soil water.

Conversely, watertables may be lowered in aquifers as supplies are drawn from them. This can cause land subsidence on a major scale, as in California's Central Valley.

Here, too, problems can arise in connexion with water management and water rights leading to conflicts and resulting in inefficiencies.

Fishing, hunting and gathering

There are communities that persist in gaining their subsistence by traditional methods of hunting, fishing or gathering or some combination of these activities. More often, however, such pursuits are supplementary to agricultural systems of livelihood, and when compared with the latter, their environmental impact is generally local and slight. When these activities are affected by desertification, it is likely that they have been damaged by adjacent agricultural systems.

Since diminished biological productivity is the hallmark of desertification, that label can be applied to circumstances leading to reductions in wildlife populations or to the loss of their habitats.

In addition to its value as a food supplement, dryland wildlife, an intrinsic part of its ecosystems, constitutes a vital element in the natural environmental balance. Its presence may therefore be essential in restorative measures to combat desertification. As part of the world's ecotypal heritage, wildlife is intrinsically worthy of preservation. As a tourist attraction, dryland animals may also serve as an economic resource.

The larger native herbivores in dryland ranges have become reduced in numbers almost everywhere. Some species are threatened with extinction.

This is in part due to heightened hunting pressure as man increasingly intrudes into the more remote dryland refuges in search of oil, minerals or pleasure. Such intrusions are increasingly made in the off-the-road cross-country vehicles by men carrying sophisticated weapons.

It is also due to deterioration of animal habitats as described in connexion with animal-based livelihood systems. As their situations become ever more precarious, dryland animals decline in both vigour and numbers.

Competition with domestic animals, whether real or merely perceived, is a factor leading to deliberate reductions in the populations of larger animals or to their exclusion from habitats they formerly occupied.

Under these worsened conditions, the impact of supplementary hunting by pastoral peoples has become increasingly severe, especially when accelerated by the general increase in human populations.

Dryland fishing communities, without considering ocean fisheries off coastal deserts, as in Peru, which are outside the scope of this review, are also subject to desertification.

Desert lakes, coastal lagoons and perennial dryland rivers support fishing industries which contribute important amounts of protein-rich supplements to local diets. For example, the Lake Chad fisheries reportedly produce an annual yield of 100,000 tonnes.

Lake Chad, however, was much reduced during the recent Sahelian drought, since drought reduces discharge by rivers and shrinks the lakes which they feed. Shallow bodies, such as Lake Manchar in Pakistan, will suffer shrinkage when the waters that feed them are diverted for other purposes such as irrigation.

Lakes and lagoons can be salinized by excessive evaporation, by the increased salinity of entering waters in irrigated regions or by the encroachment of seawater. The Aswan dam, for example, has prevented Nile sediments from reaching the beach barriers that once protected the lakes in the delta and has allowed seawater to penetrate them.

The degradation of river catchments increases siltation and generates turbidity in the lakes and lagoons fed by such rivers. This acts to kill aquatic vegetation and causes a decline in fish catches. (Conversely, the sardine fisheries in the Eastern Mediterranean failed after the Aswan Dam cut off the Nile-borne nutrients that once supported them.)

The desertification of watersheds brings on adverse changes in river régimes leading to increasingly spasmodic discharge, to siltation or flood scour in river channels and to the destruction of aquatic ecosystems.

Mining, tourism and recreation

These livelihood systems are practised in all types of climate and environment, but they take on special importance in the drylands as alternative resources in conditions of relative scarcity. Oil revenues, for instance, have fundamentally improved the prospects of a number of developing desert nations and indeed have given them the means to combat desertification. These activities have provided a fundamental impetus to the establishment or development of dryland settlements and communications. Yet they have not been carried out without environmental impact, especially in the very fragile ecosystems that make up the drylands.

Mining and mineral based industries, including the extraction and processing of oil, cause direct disturbance of vegetation, soil and terrain, not only in the actual mining operation itself, but also in such ancillary activities as the construction of roads and pipelines and the development of heavy vehicular traffic.

Disturbed and denuded soil is subject to wind erosion with increasing dust nuisance and sand drift. Disturbed ground is also vulnerable to accelerated water erosion, with consequent siltation and obstruction of surface drainage. These problems are exacerbated in drylands where water for irrigation is in short supply and where denuded ground is recolonized by vegetation only at an extremely slow natural rate.

Airborne or waterborne mining or industrial wastes cause pollution of soils and groundwater, a particularly hazardous problem in the drylands where there is rarely enough water to remove pollutants through leaching or surface drainage.

The patterns of air circulation over drylands are characterized by limited atmospheric mixing and frequent temperature inversions which hold the lower layers of air firmly in place. In such conditions, atmospheric pollution tends to hang on instead of being carried away. Held in place under brilliant sunlight, pollutants are then subject to photochemical synthesis which can transform them into even more noxious substances.

Mineral industries can bring about desertification by intense, localized competition for scarce resources such as water, wood (for fuel and construction materials), energy sources and labour. Such competition is often detrimental to local agricultural livelihood systems.

Problems arise from the impact of mining settlements in drylands. Apart from the physical impact and demands common to settlements anywhere, dryland mining towns bring with them an array of social problems related to their often temporary character, their remoteness, and to the unusual and changing composition of populations which may be wholly or partly foreign to the dryland setting.

Tourism and recreation have been drawn to deserts and drylands by warm sunny climates, a dry healthy atmosphere and natural landscapes with distinctive life forms where parks and reserves can be easily established. Drylands contain archaeological and folklore attractions and they provide ideal settings for certain kinds of sanatoria. Their popularity as tourist and recreation areas has been aided by the development of communications to and within them and has risen steeply with the increasing leisure and affluence of industrialized societies, especially those that experience cold winters. The tourist industry is an increasingly important source of revenue and employment in drylands, although complaints are often heard that the control and benefits of tourism remain outside the dryland communities. Tourism and recreation can also serve as active agents of desertification.

The construction of tourist roads and camps and the resulting increase of traffic, particularly by cross-country vehicles, is disturbing to and destructive of vegetation and soil cover in the usually sensitive landscapes that constitute the scenic attractions. This leads to accelerated erosion.

Attractive plant or animal species can be reduced or even wiped out by the uncontrolled gathering of wild flowers or by disturbing animals at critical periods in their life cycles.

Tourist settlements give rise to problems of health and sanitation, and these can be exacerbated through contacts between tourists and local populations.

Commercial tourism can have an uncontrolled impact on traditional communities resulting in interactive social complications, including the resentment of local populations at being regarded merely as objects of interest. Seasonal labour requirements have great effects on local life systems as does an increased demand for local craft products.

ryland ettlements

Aridity stimulates the formation of nucleated settlements since their necessary supports, such as water and agricultural land, tend to be localized in deserts and drylands. Depending on how "urban" is defined, between 20 per cent and 30 per cent of the 680 million people living in drylands are urban. Dryland cities include some of the oldest in the world. Today they function as irrigation centres (including oasis settlements), garrisons, communications and caravan centres, political, administrative and regional services centres, or they may be focused on tourism, sanatoria, mining or other industries.

Deserts and drylands have been subject to an accelerated urbanization over the past 50 years, often superimposed on general population increases. In Iran, for example, where the population has tripled since 1900 to a present total of almost 30 million, the percentage of urban population has increased from 20 per cent to 40 per cent. Today, the world's drylands contain nine metropolitan centres with more than one million people each. Expanding dryland cities share many of the problems of cities in more humid lands. But situated where they are, they have additional problems as agents of desertification.

Dryland communities have a direct and often adverse impact on the lands surrounding them. As concentrations of people and traffic, including livestock traffic in agricultural settlements, they are often surrounded by naked perimeters of bare ground subject to constant disturbance. Movement on such perimeters is rarely confined to established roads or tracks. The result is intensified dust nuisance and localized sand drift. After rains, these bare surfaces become muddy and filled with stagnant pools which can constitute a health hazard. Such conditions may extend right into settlements built on an open grid pattern of large blocks, like most Australian outback towns, which contain extensive uncontrolled surfaces which cannot be grassed because of water shortages.

Waste disposal in dryland settlements is confronted with particular difficulties. The disposal of domestic or industrial wastes is hampered by a lack of water for flushing or leaching, by slow rates of bio-degradation and by problems in revegetating waste dumps. This leads to chemical and bacterial pollution of soils and groundwater with attendant health hazards, particularly in more primitive conditions. Included in this problem is the impact of feedlots and slaughterhouses located in town perimeters.

Rubbish is often dumped on the outskirts of dryland towns in sparsely settled areas difficult to supervise. Dumping is encouraged by a widespread attitude that desert land is inexhaustible and otherwise worthless.

Atmospheric pollution from vehicles or the burning of fuels in cities is aggravated by the same dryland conditions that affect atmospheric pollution from mining or industry - low ratios of atmospheric mixing, temperature inversions and a high level of photochemical synthesis.

Like all towns, dryland settlements make demands on their hinterlands, and more so in developing nations where communications may be poor. Desert towns in developed economies may import many of their necessities from far away. Under any circumstances, however, the impact of the modern city on its surroundings is considerable.

Per capita consumption of water increases with urbanization, and to meet its domestic, industrial and power-generating needs, the town may compete for water with adjoining agricultural systems, as Mexico City does. Where a city is dependent on groundwater, its rising needs may lead to a lowering of regional watertables, as in the Tucson basin of Arizona, with adverse consequences for surface water régimes.

In developing countries especially, demand for wood and charcoal tends to devegetate an expanding area around the city with the usual adverse consequences. As time passes, supplies must be brought in from farther and farther away at continually rising cost to the consumer.

The expanding settlement may engulf the cultivated land that supported its earlier growth. Unrealistic land-boom sales in the United States have caused lots and roadways to be scraped out of distances often remote from towns, where they lie stagnant without further development, constituting a source of accelerated erosion. Although the growth of cities in deserts or drylands may entail smaller losses in agricultural productivity than in humid areas, such losses occur in environments that are very sensitive to disturbance and they may be very important locally.

The demand for labour by urban services and industries, reinforced by higher wages, may draw workers from adjoining livelihood systems to their great detriment. Forms of agriculture requiring intensive upkeep, such as rainfed terraced agriculture or qanat-fed irrigated cropping, have suffered particularly from labour shifts of this kind.

Just as settlements have an impact on their surroundings, so desertification of a region has an impact on cities and settlements located within or near it.

During droughts, rural peoples suffering desertification stress migrate in large numbers to nearby towns. This happened in the recent Sahelian drought, where urban population growth rates, already very high at 10 per cent per year, briefly doubled. Although towns provide a successful escape for the migrant in terms of wages and welfare, such movements impose severe burdens on urban housing and services and tend to intensify the adverse environmental impacts that cities and towns already exert.

The accelerated growth of cities, so characteristic of the contemporary world, places continuous stress on urban water resources, a stress that is aggravated in periods of low rainfall. When

desertification affects the hinterland or surrounding regions, the city's water supply can be further stressed by increasing siltation in surface water storages, reducing their useful life, and by lowered groundwater tables and a deterioration in water quality.

Desertification of surrounding lands will heighten environmental stress within the settlement. The town may experience hot winds and more frequent dust storms, particularly in periods of summer drought when local shade and shelter will also have diminished. These impacts will be most strongly felt when settlements and houses are unsuitably designed and particularly in the temporary dwellings of newly arrived urban immigrants.

V

The Human Consequences of Desertification

The impact of desertification on man

Desertification is a human problem. Its most important aspect lies in its impact on man himself - on the individual, the family, the community or the nation. The environmental degradation, the biological and physical stress described as desertification in the different dryland livelihood systems have their direct counterparts in physical, emotional, economic and social consequences for man.

As with the environmental manifestations, the impact of desertification on human beings shows a corresponding vulnerability, chronic or progressive, upon which are superimposed those critical periodic stresses that result in human disaster. Unless long-term remedies are found and applied, the passage of each crisis must leave dryland communities further weakened and still less equipped to deal with stress conditions or to confront the next crisis, which will inevitably occur, bearing with it its potential for catastrophe.

The Sahelian drought, for example, meant a drastic slash in productivity and income in the six countries most affected. Two million nomadic pastoralists lost more than half of their livestock - in the worst local situations losses exceeded 90 per cent. For almost 15 million villagers, harvests yielded less than half of the usual crop during most of the years between 1968 and 1973. The result was the destruction of already low standards of living. The repercussions were felt not only by individuals and families but resounded as disastrous cuts in national incomes.

The consequences of the Sahelian drought cannot be grasped solely in terms of its severity. It must be appreciated that even before 1968, the six Sahelian countries and the people who live in them were already among the poorest in the world. In the list of the 13 least developed countries, four of them are in the Sahel. These countries have gross national products that amount to less than $100 a year for each inhabitant. Chronic poverty and lack of capital are characteristic of desert and dryland communities in developing countries. This is a major reason why they are so vulnerable to drought disaster.

As the Sahelian drought advanced, food stocks dwindled to extinction, and famine, prevalent by 1971, was general throughout the area by 1972. It is estimated that 100,000 people died of starvation and associated disease, most of them young children. Typically, famine and disease did not strike those who had been healthy and well-nourished; it ravaged populations already debilitated by malnutrition.

Seasonal hunger and epidemic disease are facts of life among desert and dryland peoples in developing countries, where health services are usually inadequate if they exist at all. Malnutrition and low resistance to disease are among the more insidious aspects of desertification. They reduce the capacity of dryland communities to cope with periodic hardship, and they sap the will of dryland peoples to improve their condition. They must be dealt with as part of any set of measures to combat desertification.

In the pastoral areas worst affected by the Sahelian drought, there was a complete breakdown of livelihood systems and a mass exodus to towns and refugee camps located in the less affected south. Some parts of Upper Volta lost 80 per cent of their inhabitants. Many died on these migrations, but to a large number of nomadic refugees, the journey brought survival, since they found food, medical care and eventually wage employment in the towns toward which they headed. Surveys have since shown that a sizeable proportion of the pastoralist refugees may never return to their former homelands. Thus it is that the drought brought about what must be viewed as a social revolution.

On the other hand, it is possible to view such an exodus as a temporary magnification of a regular and pre-existing out-migration, both seasonal and permanent, of the nomads to the towns. Although the pastoral systems receive some benefit from the remittance of money sent from wage-earners in towns, still, even before the drought, out-migration had reached levels sufficient to cause local weaknesses and stagnation in the pastoral systems. Such movements, persisting through good years as well as bad, suggest chronic instability and the land's lack of capacity to support its populations. It is something that must be taken into account in remedial policies.

The Sahelian drought generated an international relief effort which eventually reached substantial size. Nonetheless, the effort suffered failures indicative of underlying weaknesses which existed before the drought crisis and which have undoubtedly survived it. That food and medicine could not be brought in time to those who needed them most underlines the remoteness of such regions and their lack of transport facilities. Administrative failures and bureaucratic obstacles hampered relief operations locally. Such matters must be dealt with if measures to combat desertification are to succeed.

The traditional antagonism between nomad and peasant in the Sahel, which led to inequities in the distribution of food to refugees, draws attention to the kinds of cultural conflicts and political bias which also face anti-desertification programmes. A lack of effective communication between refugees and those who were supposed to be helping them serves as a reminder that literacy rates in affected countries are sometimes very low, below 10 per cent in most countries of the Sahel, and that programmes of education must accompany measures for improving land use.

Just as dryland ecosystems react with greater or lesser sensitivity to climatic stress and the pressures of land use, suggesting an order of priorities for measures directed toward physical improvement, so differences in the inherent vulnerability of dryland communities, as reflected in the greater or lesser sufferings of their inhabitants, suggest priorities on human grounds. Full consideration should be given to whether or not international action should be directed toward the most vulnerable nations, and national action to the most vulnerable communities, rather than to areas of the greatest ecosystematic disturbance, although, of course, the two categories might on occasion coincide.

However they are ordered, remedial programmes should have as their perspective the treatment of long-term disabilities, not merely relief from temporary hardship.

Human and social manifestations of desertification

While the adverse human and social consequences of desertification become critical in periods of stress, their persistence provides evidence of chronic disabilities in marginal dryland communities. As such, they may not be specific to desertification but broadly common to families and livelihoods on the margin of the modern world, particularly in remote and hazardous environments and where tradition, social inequality or political indifference further isolate people and systems from the resources and capacity needed to effect improvement.

Among these adverse consequences are hunger, disease and premature death brought on by continued crop failure or the massive destruction of livestock, particularly in marginal subsistence societies where transport facilities are inadequate. Malnutrition increases vulnerability to epidemic diseases such as measles. Few diseases are specific to desertification, eye diseases such as trachoma marginally so, and certain diseases, such as bilharzia, are linked with inefficiencies in irrigation systems. Debility leads to further inefficiencies in another kind of cycle that may become self-accelerating.

In developed nations, such as the United States or Australia, the first noticeable sign of desertification may be loss of income. In subsistence societies, loss of income gives rise to acute problems of physical well-being and becomes increasingly important when income is dependent on the sale of crops or livestock. Loss of income is a constant problem in marginal societies, and there are a number of devices for coping with it, such as the sharing of resources or seasonal out-migration.

When drought is long-continued, there may be an incipient breakdown in livelihood systems. In nomadic societies, this stage may be marked by self-enforced sedentarization, settling down on agricultural land. Out-migration to the towns, both seasonal and permanent, may show a marked increase on the part of nomads and of those who work traditional cropping systems as well. This offers immediate relief in the form of remitted wages, but it can easily reach the point at which the local livelihood systems suffer from labour shortages, thus weakening them further. Although traditional societies have various ways of coping with such problems, some are particularly vulnerable to them, those especially which have become commercially or technologically more specialized or those in which traditional social bonds have broken down.

When the stage of incipient breakdown was reached in the disaster of the Sahelian drought, nomadic pastoral communities generally fared better than sedentary agriculturalists. In developed countries, buffering of the livelihood system at this stage may take the form of government drought relief and loans. It is likely that indebtedness will increase and the less viable holdings abandoned. Selective depopulation will occur in rural settings, while the local towns based on rural services and industries will suffer economic depression.

This process can proceed until livelihood systems collpase utterly. When this stage is reached, the greatest hardships fall on those communities that are most exposed environmentally and least equipped to transfer to a new

livelihood system. At this point in the Sahelian drought, the nomadic pastoralists suffered most, with many areas experiencing a mass exodus. As stated earlier, there are indications that many of these refugees have permanently abandoned their former livelihood systems.

Apart from the physical hardships involved, such an upheaval brings with it severe emotional stress. Those most hard hit may succumb to an apathy stemming from their felt loss of status. Social disasters of this magnitude are more characteristic of marginal societies in marginal lands. Industrialized societies have access to resources that can blunt the impact of disaster.

VI

Measures to Combat Desertification

Principles which should guide all measures against desertification

Any measures undertaken to combat desertification must be informed by certain principles long recognized by the Member States which compose the United Nations. While some such principles may seem predominantly humanitarian in character, the fact is that they are also intensely practical. Desertification is a human problem, and measures to combat it involve people, especially those most affected, who must be convinced of the virtue and practicality of participating in the measures proposed.

Measures to combat desertification must be seen as having human and social objectives. They must be inspired by an acknowledgement of the right of people living in drylands to acceptable standards of health education, livelihood and social well-being, consistent with human dignity.

Account must be taken of traditional social values and an appropriate respect shown for life styles and ancient knowledge developed in harmony with the dryland environment.

Priorities in programmes to combat desertification should be influenced by the severity of its impact on the populations concerned, and by the degree of their vulnerability.

The approach should be an integrated one, in which proposals involving technological or environmental change are linked with social and economic measures.

Measures to combat desertification will not succeed without the willing participation of local communities. The need must be recognized to work through existing livelihood systems and established social patterns. The involvement of the community must be sought, as by enlisting the example of local leaders. Educational and publicity programmes must be designed with this in mind.

It may be necessary to create incentives toward community participation. The practicality and advantages of proposed measures should be demonstrated at the earliest stage through realistic pilot projects.

From the outset, programmes should contain some measures selected because they relate to immediate local problems, because they demonstrate prompt action within the community, because they are possible with existing resources, and because they promise convincing results within a reasonable time.

Advantage should be taken of crisis situations, when societal and livelihood systems have been disrupted and people are more prepared to consider change and to carry out whatever restructuring of dryland livelihood systems that conditions may call for.

Campaigns against desertification must be realistic and planning should not set goals which can neither be supported nor achieved in regions of essentially low productivity.

The ideal objective is the recovery and maintenance of ecological balance in the drylands in the interests of sustained productivity, but this must be reconciled with the needs of local populations. Some degree of environmental disturbance must be tolerated in land management.

On the other hand, it must be accepted that land-use pressures have been a major factor in existing problems of desertification. Any effort to improve conditions must recognize that fact. Accordingly, changes in land use will be required, and these bring with them a need for corresponding social changes. Some element of control will obviously be required, but it will not succeed without a sympathetic community response. This must be sought through education, demonstration projects, and a sense of involvement and shared decision among the local people.

Where limits are set by rainfall, the productivity of drylands per unit area will never be anything but low. Such lands can command only modest investments in keeping with their productivity. Reclamation and preservatory measures should be designed in accordance with this outlook, as should the goals of redevelopment schemes.

Since rainfall will remain variable in the drylands, they will continue to be high-risk areas for most land-use systems, and this should be reflected in development plans. However, measures to stabilize their livelihood systems and buffer them against periodic drought should not deprive them of their flexibility and the risk-spreading strategies characteristic of traditional dryland practices.

Apart from limitations set by climate, dryland ecosystems will remain sensitive to land-use pressure because their soils and dynamics are delicately balanced. The best designed dryland livelihood system will still require constant surveillance if balance is to be sustained. It is therefore essential that campaigns against desertification should not be presented as sets of single episodes. Development plans must incorporate systems of monitoring and maintenance. This requirement strongly underlines the need to develop indigenous science and technology.

The drylands and their threatened margins cover more than a third of the earth's land surface. As might be expected, a scope so immense comprises a vast variety of biophysical, economic and social settings. Desertification and its problems are correspondingly varied and complex. Any plan of action to combat desertification will recognize this, and with it that there can be no single set of remedies. Recommendations must take account of different situations and be flexible enough to encompass a wide range of conditions.

Review of the desertification problem strongly supports the contention that past failure to maintain balanced livelihood systems in drylands is the outcome of an inability to apply existing knowledge of physical processes rather than from any lack of understanding of what the processes are. The same appears to be true of the design of measures to combat desertification. Accordingly, plans of action should address themselves particularly to the removal of obstacles to the application of existing knowledge, to the adaptation of existing knowledge to local situations in the social as well as in the physical sphere, and to problems of acceptance and participation among local communities. Plans of action should stress action rather than future research.

It should not be taken for granted that action to combat desertification will take first place among national commitments. The Plan of Action to Combat Desertification should not appear to pre-empt already established national priorities. Nevertheless, it should be kept in mind that action on the ground will largely be carried out by national organizations, and presentation of the plan should accordingly aim to influence national governmental attitudes toward the problem of desertification and should seek to secure the active commitment of governments. This is most likely to occur when combative measures are linked to broad national plans for development and appear to be consistent with national goals.

Because dryland ecosystems are fragile, they are particularly vulnerable to misapplied technology. Techniques and equipment tried with success in more humid regions have contributed to desertification in drier environments. When innovations are suggested, attention should be paid to the impact they will have on the dryland environment and to their adaptability to local livelihood systems. In developing countries, attention must also be paid to low cost, simplicity of operation and acceptability by the local community. It follows that modifications of existing technology and practice are likely to prove more effective than radical innovation.

Beyond these guiding principles, measures to combat desertification must take as their point of departure the identification of the process when it occurs and the assessment of its nature and severity.

Identification and assessment of desertification

Experience indicates that the long-term progressive deterioration of areas that constitutes desertification may not be readily identifiable against the background of short-term environmental fluctuations that spring from periodic shifts in the rainfall. There is a consequent need for regular monitoring of the status of dryland ecosystems to provide early warning of trends, to identify areas in which change is taking place, and to provide a basis for the investigation of causes and processes. It is in terms of such information that measures for prevention or reclamation will ultimately be designed.

Because the problem is global, calling for international effort and a worldwide exchange of information, monitoring should be established in the form of uniform, worldwide surveillance. Such arrangements might usefully be identified and co-ordinated as a "world desert watch".

Global surveillance of the status of dryland ecosystems and of land use can be achieved most economically through the remote sensing powers of specialized orbiting satellites. The so-called LANDSAT system, already in operation, has this capacity. LANDSAT now provides imagery at a scale of 1:250,000, with prospects that a scale of 1:100,000 will soon be achieved.

The first step in the use of a satellite such as LANDSAT is to employ it for the identification and mapping of distinct units on the ground. This can be carried out in false colour imagery (LANDSAT bands 4, 5 and 7) or in black and white. Much of the world's drylands, perhaps 85 per cent, is already covered by LANDSAT. The mapping would define functional environment types as determined by their geology, landform

and surface drainage, each type characterized by certain soils and vegetation cover. The characteristics of each unit would be established from imagery and supported by already existing information on geology, soils and vegetation. The findings would be validated on the ground, this so-called "ground truth" being determined by field sampling and traverses.

Initial demarcation of the topographical and soils units by a skilled photo-interpreter would be inexpensive, costing in the order of some dollars per thousand of hectares. The building up of ground truth would be a separate and continuing operation. Different combinations of boundaries would allow the information so obtained to be expressed in terms of a variety of references, such as pasture land, vegetation or salinity. The achievable scale would be adequate for general surveys of land status, for planning for extensive land use such as pastoralism, or as a first stage in the identification of likely areas for more intensive kinds of land use. The maps obtained could provide a framework for the interchange of experience between comparable environments.

To fix trends in dryland ecosystems repeated monitoring on a uniform basis is required. This can be obtained from the LANDSAT system via remote sensing satellite-to-ground receiving stations. Each of these has an effective radius of about 2,700 km. but at the present time, only a part of the drylands is properly covered. Access to a ground receiving station provides an opportunity for manipulating the data output to conform with local needs.

The storage, handling and reproduction of the data from the ground-receiving station, and its integration with data from other sources, calls for linked computer-based data systems which will generally form part of a national land-data system. Information can be related to a given topographical unit or to another geographical subdivision by the use of a standard system, and experience suggests that a one-to-two kilometre grid provides adequate definition for the general surveillance of drylands.

A feasibility study set in South America is proposing to validate a transnational approach to monitoring desertification on the above basis. The annual cost of establishing a ground receiving station and linked data system would be $2 million, which amounts, as suggested, to dollars per thousands of hectares covered. The establishment and validation of such a system using pilot test areas would take about three years, and such systems are not likely to be generally established before five years. It looks as if world coverage would be most economically achieved through regional groupings of countries.

LANDSAT imagery will have to be reinforced by ground truth from periodic field surveys, measured transects and other types of ground-based reporting.

The further investigation of areas revealed by LANDSAT as undergoing desertification or as potentially suitable for more intensive

land use will call for mapping and monitoring at the finer scales provided by conventional air photography.

The evidence obtained from satellite imagery and other sources, linked through the data bank, should provide the basis for a number of important activities.

The first of these should be the construction of a map showing types of desertification present and the relative vulnerability of the demarked ground units to further desertification. Then regional plans can be formulated for measures to combat desertification, linked with plans for improved land use, for resettlement, or for whatever else conditions call for. Following the regional plan, specific combative measures can be designed and sites selected for demonstration or pilot projects.

Monitoring will continue, both to maintain surveillance of land use systems and to provide assessment of the progress of combative measures.

The conditions of dryland people must also be assessed.

If measures to combat desertification require continuous assessment of vulnerable lands, they demand also a comparable understanding of the people who live in such places. Experience with existing programmes has indicated that physical problems associated with desertification are commonly more amenable to solution than the typically human problems.

Assessments of physical conditions should therefore be accompanied by efforts to obtain a more precise understanding of the state of dryland peoples. Surveys should be undertaken, perhaps through a strengthening of census services and techniques, of their demographic characteristics of the state of their health, and of their social and economic circumstances. On the basis of what the surveys reveal, measures can be designed to combat malnutrition, ill health, poverty, illiteracy and other social and economic disadvantages commonly suffered by people living in the drylands. Social and economic changes, such as resettlement or alternative livelihood systems, should be presented and proposed as integral parts of a plan to improve conditions and not as mere afterthoughts to environmental measures.

If plans are to succeed, they must be acceptable to local communities. Social, economic and technological acceptance are likely to be as important as environmental compatability in determining the effectiveness of what is proposed. Studies should be directed toward uncovering obstacles to community acceptance and to ways in which acceptance can be gained.

In order to obtain the agreement of local communities and their participation in measures to combat desertification, the planning process should maintain close contact with community leaders and involve them at all stages, while preparatory studies are looking into a number of matters directly involving the local people.

One such matter would concern how people can be best be approached through publicity and education on the nature and consequences of desertification and the need for action to combat it. A study might by made of what social and economic incentives would best contribute to community participation.

Some demonstration projects should be designed and executed that are easy to do and produce prompt and desirable results. People must be persuaded that action against desertification will work, that it will improve their lives and that such campaigns are more than idle talk.

Whether they concern land or people, plans must be flexible. They should incorporate periodic checks on the progress of measures put into operation and should allow for concurrent reassessment of the problem in human as well as in physical terms.

Measures to combat desertification will take on distinctive characteristics depending on the nature of the land and the livelihood systems practised there.

Measures to combat desertification in extensive pastoral systems

In pastoral systems, desertification makes its appearance primarily in the degradation of natural pastures following over-grazing. It shows itself in wind erosion, sand drift and dune advance, in gullying where stock have concentrated and trampled the earth or where cutting or uprooting of woody vegetation has laid bare the surface.

To combat desertification in these circumstances means in general to adopt grazing practices that will allow the native vegetation to recuperate. In areas too dry for rainfed cropping, the natural vegetation usually forms the most efficient pasture in terms of upkeep, grazing returns and protection of the soil surface. The maintenance of a plant cover that will sustain the pastoral system under most conditions is the obvious goal of combative efforts. Anything more - intensive reclamation, for example, by planting programmes or mechanical controls - will be feasible only in restricted areas where the physical processes of desertification threatens installations, communications, settlements or valuable cropland.

It is basic that pastoral systems accept the principle that their fundamental resource resides in the dryland pasture rather than in the livestock. The experience of the Sahelian drought indicated that the death of livestock was chiefly due to the failure of pastures rather than of water supplies. Accordingly, conservation measures should be introduced for the control of grazing access to dryland ranges where such measures do not exist, including fencing when necessary.

As a first step, surveys should be initiated to determine the useful productivity of the main varieties of dryland pasture under differing seasonal conditions, the requirements of pasture plants for successful regeneration under grazing, and the dimensions of the grazing impact of a proposed system composed of certain animals in certain numbers. Surveys must take into account the dual rôle of perennials as

surface protectors and as fodder during drought. A logical first step in the assessment of dryland pastures is to map them, indicating the distinct topographic, soil and water conditions. Maps can be prepared inexpensively from satellite imagery or conventional air photographs.

Surveys lead to assessments of carrying capacity under a variety of conditions and these, in turn, form the basis of appropriate grazing strategies. Such strategies should include a number of elements.

They should incorporate possibilities for deferred or rotational grazing and for the establishment of protected reserves as seed reservoirs, grazing reserves in the event of drought, and plant and wildlife refuges in which genetic variety can be conserved. As far as possible, they should preserve the mobility, flexibility, diversity and low stocking rates traditional in dryland grazing systems. Consideration should be given to fencing those parts of the rangeland subject to concentrated stock movements, those made up of particularly vulnerable pasture types because of soil or the formation of the land, or such sensitive areas as town perimeters.

Opportunity should be taken to enrich natural pastures locally by developing simple water-harvesting schemes, such as by the construction of trenches and flood banks in areas of natural flooding. These areas should generally be treated as controlled reserves, available for the breeding of animals, as a resource against drought and for the harvesting of forage. Consideration should be given to using such areas for subsistence cropping. They should be fenced off from the open range and their use integrated into the general grazing scheme.

Range conditions should be periodically surveyed to determine what grazing pressures are doing to the land and vegetation and with a view to adjusting the grazing system when required. Satellite imagery and air-photographs are now in use for continuing assessment of plant cover and productivity, but remote sensing must be supplemented by ground surveys in carefully selected areas.

While grazing strategies refer to average stocking rates, attention must also be given to localized concentrations, as along tracks and around watering points and settlements, and measures should be taken to avoid intensive local grazing and trampling. An example might be the establishment of watering points of moderate size in a network that gives adequate access to all pastures being grazed. Measures should be introduced for the controlled and responsible use of such watering points, including the levying of charges on graziers who use communal supplies.

When the trend of rangeland conditions indicates that grazing pressure should be reduced, a number of measures can be taken. They might include the improvement of transport facilities, assistance with breeding programmes to improve productivity per animal and measures to reduce the risk of losses from breeding herds. Marketing outlets should be established for the efficient disposal of surplus animals, for example in stratified management programmes as suggested by the SOLAR feasibility study, with subsidies and price supports where necessary.

Although pastoral systems have proven efficient in their use of extreme environments, experience indicates that these livelihood systems share fully in the climatic risks of such environments, with adverse human and physical consequences. Although they should not be buttressed to the point of losing their adaptive flexibility, they need help in coping with recurrent drought stress. A number of measures can be taken to provide this help, such as the setting aside of grazing and forage reserves, the provision of transport facilities for the movement of stock, financial assistance to restore herd numbers following drought, and insurance against drought losses.

Mutual support from adjoining crop-based systems has traditionally provided pastoralists with an important safeguard. Such arrangements should be maintained and strengthened where possible. They have included market exchanges, arrangements for stubble or fallow grazing (in exchange for natural fertilizer), and the introduction of forage crops into crop-based systems. Arrangements vary widely, from the incorporation of seasonal nomadic pastoral systems into schemes for irrigated agriculture, as in the south-eastern USSR, to the integration of animal-based and rainfed crop systems in zones of controlled land use, as in green belts around the Sahara.

Measures to combat desertification nomadic pastoral systems

Recent years have shown an increased tendency for pastoral nomads to settle down in fixed habitations. This happens because of changing personal goals or attitudes, because of drought disaster, or as a result of government programmes. Nomadic herding is then left to part of the former community, which comes increasingly to resemble more settled pastoral systems. These changes will continue, and assistance should be given to accommodate them.

Such assistance might take several forms. Consideration might be given to the establishment of properly designed settlements equipped with water supplies and community services. Nomads can be aided to develop ancillary farming, whether irrigated or rainfed, particularly for subsistence or forage crops. Wherever nomads have settled down, measures should be taken to reduce the environmental impact of stock concentrations or fuel-gathering activities among people unaccustomed to living in permanent settlements. Woodland or range reserves can be established near settlement perimeters.

Over recent years, nomadic pastoralists have been increasingly at a disadvantage relative to adjacent farmers, particularly during periods of above-average rainfall when cropping tends to encroach on pasture lands. Care should be taken to preserve the traditional access by pastoralists to rangelands and watering points, by legislation or taxation policies if necessary.

Little had been done to strengthen nomadic pastoralism by using traditional practices, with all their adaptations, as a base. Measures could be taken to improve livestock quality through breeding programmes in an effort to increase yields from smaller herds and decrease losses through disease. Control of grazing can be effected through technical advice, preferably directed toward the reinforcement of traditional

practice and authority. Breeding and marketing schemes can be developed in harmony with traditional systems. Additional watering points can be provided that are moderate in size, cheap to construct and easy to maintain. Here the use of windpumps should be investigated. The use of such waters should be controlled to conform with broad grazing programmes and should aim to bring all pastures into effective use.

These animal-based systems are often at the extreme edge of environmental productivity and are therefore vulnerable to periodic extremes of protracted drought. This situation should be recognized by setting aside food reserves and in the advance planning of emergency measures.

The seasonal or permanent out-migration characteristic of these communities has long provided them with supplementary income in the form of remittances from once-nomadic wage earners. Plans to combat desertification should seek to accommodate and assist such population movements through appropriate resettlement schemes. Alternative sources of livelihood might be provided in the local setting, as through employment in tourism, craft industries and services or through the establishment of new industry or agricultural activities. Attempts should be made to reduce the selective out-migration of the most able workers whose loss tends to impoverish the local community.

Measures to combat desertification in commercial ranching systems

Commercial ranching differs from more traditional animal-based systems, and often in ways that make it more vulnerable to desertification.

Commercial ranching tends to be more settled, less free ranging, with greater likelihood of disturbance around fixed installations. Attention should be given to arrangements for moving and yarding stock, and some installations, such as yards, paddock gates and troughs, may have to be shifted periodically to avoid extreme effects.

The use of mechanized transport and other equipment characterizes commercial ranching. Care should be taken in routing and grading tracks and roadways, especially where protective stone covers are involved. Attention should be paid to possibilities of stabilizing surfaces as an alternative to grading fresh routes. Particular care is required where runoff is channeled along tracks or their margins.

High labour costs in commercial ranching mean a minimum use of manpower, which causes difficulties when labour-intensive measures, such as planting, are called for. Proposals for pastoral development should include an assessment of environmental impact and an estimate of the likely costs of reclamation measures, an expense that may be made tax-deductible.

Vulnerability to price fluctuations, including those on distant, international markets, introduces an additional hazard into commercial ranching systems, reinforcing the hazard of climatic variability. Depressed markets may lead to the abandonment of properties and the loss of installations and may discourage appropriate long-term investment. Government-assisted marketing and price-stabilization schemes should be introduced when necessary.

At the same time, commercial ranching has some characteristics which give it advantages in combating desertification.

These include lower stocking rates, better control of stock movements and watering points, and improved facilities for the transport of stock and forage by road or rail. Such advantages point to the need for more imaginative stocking policies, particularly those that avoid extreme grazing pressure. Enlightened policies would include the maintenance of grazing reserves on the ranch and even more extensively on the unalloted or public rangelands within the pastoral district. Provision should be made in advance for the transport of stock to such reserves when circumstances require it, for de-stocking in times of drought and for re-stocking when the rains return, and for access to forage when drought occurs. Such provisions may call for outside assistance.

Mechanized equipment can be used to counter extreme desertification in local situations. Encouragement should be given to research on improved methods of revegetation, including soil treatment, pitting or furrowing, seeding and fertilizing. Assistance might include technical advice, the loan of plant stocks, the provision of seeds and fertilizers, and financial subsidies for approved measures.

In operation, commercial ranching can take advantage of economies of scale. It is also more subject to governmental regulation, either directly through lease provisions or indirectly through financial or taxation policies. Recommended stocking practices can be enforced through these means, which can also be used to achieve the subdivision or amalgamation of holdings so as to favour operations on recommended lines.

Combating desertification in rainfed cropping systems

Rainfed agriculture, embracing much of the world's production of staple cereals, extends across semi-arid and sub-humid lands subject to brief but intensive rainfall. In these systems, exposure and loosening of the ground surface facilitates erosion by wind and water. When the systems are mechanized, extreme clearing increases the impact of wind. Desertification appears in the blowing away of topsoil, in sand drift and the local growth of coppice dunes, in sheet erosion and gullying on sloping ground and the deposition of infertile alluvium on bottom lands. When these events occur, productivity declines and croplands are abandoned.

Although it covers less territory than pastoral systems, rainfed cropping supports larger dryland populations, and the potential losses through desertification, in terms of both capital and livelihood, are correspondingly greater. The impact of desertification is intensified because denser settlements and more intensive communications are associated with rainfed agriculture.

Great problems have arisen through incursions by cropping systems into areas of excessive climatic risk. This commonly happens during wetter years, when farmers are attracted by the prospect of short-term gains. Such invasions are usually made at the expense of adjacent pastoral systems, and they commonly end in the collapse of the intrusive cropping system when drier years return, sometimes with the land so damaged that it is no longer suitable for grazing.

Studies of the relation between agriculture and climate, such as those carried out by the World Meteorological Organization in Western Asia and Saharan Africa, have done much to determine the connexions between climate and the water needs of cereal crops, thus fixing the probability of the occurrence of effective seasons on the basis of climatic records. These studies should be extended and improved through additional meteorological recording and investigations into the water requirements of crops at different stages of growth and under a range of soil conditions.

Such studies, by providing good estimates of climatic risk, will support policies of land zoning, and measures should be taken to discourage the extension of cropping beyond certain climatic limits.

At the same time and because cropping represents a more productive use of the land, attempts should be made to expand the safe-cropping area by introducing strains or types of crops that are more resistant to extreme conditions and through improved methods of cultivation and water conservation. Such actions should be supported by demonstration projects and extension services.

Research should be encouraged that will lead to improved weather forecasting with accompanying warning systems, particularly for such critical periods as seeding, germination and harvesting.

Rainfed systems have also been extended onto steep slopes and very fragile soils and into areas subject to flooding, particularly under the pressures of population increase. The result has been accelerated erosion, lowered yields and the loss of cultivable land. These are common occurrences when uplands have suffered deforestation with a consequent increase in runoff and water erosion at lower levels. Such developments are well exemplified on the Mediterranean margins of the Old World deserts.

It is essential that plans for the reclamation and improved use of rainfed croplands should form part of integrated schemes for the use of functional areas such as drainage catchments and which recognize the interdependence of upland, piedmont and valley with their associated land use.

A first step in formulating a plan is to map land types and land use at a scale appropriate to cropping (1:50,000 to 1:250,000, depending on conditions); The land units mapped should be classified according to potential use as determined by the existence of hazards, such as steepness and length of slope, the presence of stones or rocks, the risk of flooding, the quality of the drainage and vulnerability to wind erosion.

Recommendations as to how the various parts of the land should be used will constitute the plan, which must recognize appropriate limits to rainfed cropping, as determined by rainfall, terrain, soils and relationship with adjacent land uses such as forestry or grazing. The marginal lands outside these limits should be removed from cropping by acquisition, such measures as financial inducements or by the establishment of forest, grazing or water-catchment reserves. When such measures

involve the disruption of traditional livelihood systems, they are unlikely to succeed unless they form part of larger schemes of rural reconstruction involving appropriate changes in land tenure, such as the consolidation of holdings, or resettlement schemes offering alternative livelihoods.

Clean fallowing, or allowing a field to rest while stripped of vegetation, provides a way of conserving the moisture in the soil. Like several such techniques, clean fallowing happens to increase the land's vulnerability to desertification. Safeguards can be erected by improved methods of rainfed cropping, measures which maintain ground cover and improve soil structure. The things that can be done to counter risks and improve productivity vary considerably among different situations and different systems of rainfed agriculture.

In regions of a Mediterranean type, traditional combinations of tree and field crops should be encouraged. An element of livestock husbandry should be retained, increasing the diversity of these systems, their resilience, and hence their resistance to climatic stress.

In some Mediterranean regions, decay and disuse have affected certain traditional methods for the conservation of soil and water, such as terracing and water-spreading systems. These old systems should be brought back into service, maintained and even improved, and assistance should be provided for such purposes. Tree planting should be encouraged, whether in shelter belts or in coppice groves for firewood. Tillage should avoid powdering light topsoils, and farm machinery, some of which may have to be designed, should be suitable for working such situations as terraced slopes. Strip cropping should be introduced as a counter to wind erosion. More use should be made of crop rotations, including legumes, at the expense of fallow.

Crop rotation, including cover crops to be ploughed back into the soil, should also be introduced into mechanized systems of rainfed monocropping. Such systems should restrict the burning or removal of litter, and livestock should be introduced to graze on feed crops or crop residues. Strip cropping should be encouraged, with inducements on occasion, as well as the planting of shelter belts on open plains. To combat salinization on valley floors, deep-rooted varieties or salt-tolerant pasture can be planted.

In the swidden system, the slash-and-burn agriculture so typical of rainfed cropping in drylands with summer rain, the farmer will return to a particular plot after its vigour has been restored by extended fallow, often after as long as twenty years. Shortening the cycle, coming back too soon, can have adverse effects on plant recovery and regrowth and on soil fertility. When this happens, measures should be taken to restore the cycle to its older rhythm, perhaps by expanding the area available to cultivation or by removing population pressures through resettlement or the development of alternative livelihoods.

In these systems, valuable substances, such as gum arabic, can sometimes be extracted from the natural regrowth during the fallow part of the cycle. Steps can be taken to increase the value of regrowth by introducing new trees or by adopting good forestry practices.

Traditional crops and ancient tillage practices have sometimes become fixed in these systems where new varieties and alternative techniques would work better to maintain the fertility and structure of tropical soils and to diminish the effects of pluvial erosion and soil crusting. Swidden agriculture should be closely scrutinized everywhere with a view to reducing its impact on the land.

Once rainfed cropland has been degraded, efforts to rehabilitate it should form part of larger actions directed toward water management, improved land use and the control of erosion. Within broader plans, quite definite actions can be taken depending on the form that degradation takes.

Gullying, a particularly unsightly form of erosion, can be arrested by planting trees in upper catchments and along gully margins and by grassing areas that feed the gullies with flows. Also helpful are the construction of diversion banks and furrows across gully heads and the installation of check dams and silt traps along gully courses. Under favourable conditions, gullies can simply be filled in and their banks regraded.

Sheet erosion, which scours topsoil from wide areas, can be countered with contour banks and ditches, with grassed contour strips and by means of terraces.

Wind erosion, which blows soil away from rainfed cropland and which causes sand drift and dune encroachment, can be countered by planting shrubs and trees in shelter belts (at a spacing four times as far apart as their eventual height).

Fences can be constructed or lines of resistant shrubs and trees planted as barriers against oncoming sand, upwind of threatened areas. Bare sand can be covered with matting, bituminous coating or mulches of vegetation litter.

Sand surfaces can be stabilized by seeding and planting proper successions of vegetation, including plants which thrive in sand, legumes and cover plants in association with shrubs and trees, supported by irrigation where necessary. Finally, dunes can be levelled or reshaped to remove slip faces.

Combating desertification in irrigated cropping systems

On turning to irrigation systems, a harsh fact is promptly encountered. The amount of irrigated land lost annually to desertification (some hundreds of thousands of hectares) is probably about equal to the amount of land newly brought under irrigation each year. Great costs are involved in the breakdown and abandonment of such intensive, highly-capitalized agricultural projects. Irrigable land is scarce, and new enterprises are enormously expensive. Such considerations stress the importance of maintaining existing irrigation schemes by countering desertification whenever it affects them.

The most prevalent form of desertification in irrigated cropping systems occurs when waterlogging causes salts and alkalines to infect soils, particularly where drainage is poor and proper leaching fails to take place.

That particular problem emphasizes the importance of preliminary surveys and testing of proposed irrigation projects to assure adequate design. Most salinization problems arise from design deficiencies.

Good design should be based on an understanding of how much water is available for irrigation and its silt and salt loads, including seasonal variations. A close study must be made of the soils in the area embraced by the project, their texture and salinity, and especially of their water properties, as these will determine drainage requirements and how much water will be available to crops. Water requirements should be determined for proposed cropping systems. The position and salt content of the groundwater table should also be determined as well as seasonal fluctuations in both. This will require some understanding of the hydraulic properties of the soil's lower layers, or how those layers store and transmit water.

These investigations should yield a map showing salt hazards and how they might restrict the proposed cropping system. On the basis of the map and the surveys, design work can continue with particular emphasis on the distribution of the water and effective drainage systems and the subdivisions of the system as determined by estimated water needs. Finally, design should take account of the services and communications the system will require and the settlements that serve and are served by it.

Whether under development or in operation, irrigation schemes should be run by operating authorities equipped with professional staff, adequate funding and the powers to control land use. As a way of proceeding, especially with new schemes, the authority should undertake pilot projects which can be expanded into research and demonstration projects as they prove their worth.

Irrigation schemes require extensive maintenance. The main distribution canals should be properly banked and lined, as with concrete, to reduce seepage. Canals and drainage ditches should be kept clear of silt and weeds and pools of stagnant water eliminated. Take-offs or turnouts, where water is drawn into the system, should be designed and maintained to keep silt loads to a minimum.

The plots to be irrigated should be levelled to ensure even watering and leaching, and where local subsidence occurs, levelling should be carried out periodically. While provisions and requirements for adequate leaching should be maintained, there should also be checks a against over-irrigation.

Irrigation schemes are sometimes established where farmers have neither familiarity with nor tradition in this type of agriculture. Yet the tillage of heavy soils under irrigation calls for particular skills, as does the application of irrigation water at prescribed stages in the development of the crops. Extension services must be provided if irrigation schemes are to work successfully. Land-holders should also be given assistance in the form of credit, purchasing and marketing plans, and where suitable and desirable, in the development of agricultural co-operatives. Improved land use should be encouraged through such measures as economic incentives and tax concessions.

When irrigation schemes are designed, individual or family holdings should be shaped to ensure an appropriate level of intensive use, without being too large to preclude effective maintenance. Encouragement should be given to an appropriate balance of subsistance and cash crops, tree and field crops. Forage crops may be included if circumstances favour a livestock component. Great care should be taken in the allocation of holdings and in the formulation and administration of regulations for their proper management.

When successful, irrigation schemes inevitably give rise to close settlement, to towns, usually inhabited by people unaccustomed to congestion and its attendant problems. Housing should be planned for and provided at the same time that land holdings are allocated. Houses should be equipped with potable water and sanitation services, and all the more so here, where diseases can be transmitted through the irrigation system itself. Indeed, new communities should be provided with all the standard community services, including health, education, welfare and cultural centres, and these should be sited as part of the land settlement plan. Transport services should be established.

Irrigation projects based on groundwater supplies encounter special difficulties because groundwater quality is usually lower than that of surface waters and the threat of salinization is generally higher. Limitations in groundwater supplies may hinder proper leaching. Groundwater supplies must be kept in balance with the requirements of land use, and enough water must be provided for both irrigation and leaching. Generally, discipline applied to water use must be stricter when irrigation is based on groundwater rather than surface water.

Such discipline may include central control over the siting of bores and wells and the installation of pumping equipment. Monitoring must be constant of such factors as groundwater levels, draw-down and salinity, and the proper staff must be on hand to conduct such monitoring or any other investigations as required.

When based on groundwater supplies, irrigation schemes often suffer from poor drainage, with increased chances that the groundwater supplies will be contaminated by saline irrigation runoff. Such schemes are often characterized by networks of small distribution channels under individual control affected by wastage through seepage and higher risks of salinization.

Many such problems arise because older groundwater-based irrigation projects often grew up without any planning, and their operations remain hampered because of entrenched rights to land and water. Some of these old projects should be rationalized, with compensation when necessary. Groundwater assessment together with the mapping and classification of land types - the information used to plan a new system - would provide a basis for rationalizing older systems and for their continuous reassessment.

When irrigated lands have suffered salinization or other forms of desertification, they should be surveyed as a first step to reclamation. By determining what topographic changes have occurred, the degree

of salinization of soil and groundwater amounts and levels, an estimate can be made of what is needed to leach and drain affected lands and what else might be required to restore the system - by relevelling of ground surfaces, for example, or renewal of irrigation channels. How drainage will be effected - whether by tube wells, tile drainage or open ditches - will depend on groundwater conditions, soil properties and costs of land and labour.

When the situation has been made clear, decisions can be made on priorities, which might include abandonment of lands most severely affected, and a reclamation programme designed in terms of the availability of water, labour and capital. After the programme has been implemented, reclaimed lands can be re-allocated, but not without clear regulations on what can be done with them. Reclamation provides an occasion for the enforcement of practices that will prevent desertification from recurring.

Combating desertification in mining

The drylands have always held vast treasure in mineral resources, including the modern world's petroleum, and it can be expected that new discoveries will be exploited there in a now familiar pattern: Revenues will be large compared with other local sources of income; direction and financing will come from outside the region, and almost all financial benefits will be exported away.

In the past, or so it generally seemed, such resources would have been exploited whatever the local human consequences and environmental impact. Nowadays, it is agreed that the region and the local community should be protected from the worst consequences of such exploitation, which is indeed expected to make a proper contribution to regional development and welfare. To assure this, mining proposals must contain an assessment of their environmental impact, and the proprietors of the mines will be expected to meet the full costs of environmental protection and reclamation. Their operations must be so conducted that they contribute to the general development of the region.

It may be difficult to maintain principles when great riches are involved, but in any competition for scarce resources, such as water or land, the rights and needs of the local community should receive priority. When mining or drilling operations are about to be introduced, the local people should participate fully in planning and in all other decisions that concern them, and arrangements should be made for continuing consultation.

The drylands should be favoured with the same standards of environmental protection that are applied in more humid areas. Indeed, drylands may require additional precautions because of the special sensitivity of the arid environment, its susceptibility to air pollution, groundwater pollution, dust nuisance and surface disturbance. As an example, restrictions should be placed on the grading of unsealed roads in drylands and on their use by heavy vehicles.

The activity of mining or drilling and the people who carry it out, many of them brought in from outside, will have all sorts of effects

on the surrounding region. Plant and animal reserves may have to be established on the perimeter of the activity, with restrictions on hunting or plant removal over a wider surrounding area. Employees brought in from outside should be placed in suitably designed settlements equipped with proper services.

Mining or drilling ventures will view local communities as a source of labour and a supplier of food and materials, and fulfilling these rôles can affect a community adversely. It sometimes happens that a once-isolated, traditional society is brought into sudden contact with people of a very different kind, often rootless, sometimes violent, accustomed to a transient, unstable society. It will be difficult to maintain the principle that the rights and needs of the local community should be protected and local people are given every opportunity to participate in and benefit from the new development.

Combating desertification associated with tourism

Many of the considerations relating to mining and drilling have equal application to tourist activities and installations in deserts and drylands. Local communities should share in the benefits of tourism. It should provide them with opportunities for employment, improved communications and access to other support services and improved markets for local products, including those of craft industries. But before local communities can share in the benefits of tourism, they may have to be protected from it.

For example, local livelihood systems, such as pastoralism, may have to be protected from interference by tourist activities. The information tourists are provided should include comments on the local people, their customs and way of life, to help ensure respect for their practices and for themselves as persons. Protection may have to be given to sites and objects of traditional cultural importance. In the competition for scarce resources such as water, land and pasture, the needs of local communities should be assigned first priority. This viewpoint and the protection required may best be achieved when local communities participate in the planning and management of tourist activities.

The natural environment will also require protection against tourist activities. Great care must be taken in the siting, design and maintenance of tourist roads, camps and rest areas. Traffic restrictions will be needed, particularly on the use of cross-country vehicles, and roads subject to heavy traffic will have to be paved. Lodges and camps will have to be served with proper facilities, for water, sanitation, rubbish disposal and the control of local traffic. Penalties should be applied to combat littering. Plants and animals will require protection, particularly of endangered or attractive species. Archaeological and scientific sites, interesting geological formations and natural monuments will all require special protection.

The concept of environmental management, so important to sustaining productivity in agriculture, should be extended to the tourist industry. This might involve the establishment of reserves or wilderness areas from which tourists would be excluded and which would serve as refuges

and sources of regeneration for plants and animals. Or it might embrace the concept of natural parks for controlled tourism in which the tourist could view an interesting and typical range of natural ecosystems without causing them damage. The management of such parks should incorporate the concept of "recreational carrying capacity" with "deferred" or "rotational" uses to allow for the seasonal vulnerability of species and to spread the impact of tourism. It is obvious that such parks must be adequately staffed with professionals capable of providing tourists with expert guidance.

The development of tourism should be generally controlled in the interest of environmental protection. Such control can be exercised by tourism ministries or tourist boards on which local communities and land users are represented or can be heard. Each tourism proposal should be required to incorporate an environmental impact study, and approval of the proposal should be subject to the provision of adequate environmental protection. The costs of such protection and of reclamation, if subsequently needed, should be borne by the project.

Combating desertification associated with human settlements

Dryland settlements can range all the way from the one-family homestead with its thorn-tree fencing to great, modern cities with millions of inhabitants. The usual dryland settlement, however, will be a village or small town that has grown up to serve the needs of the livelihood systems practised in arid settings. A number of measures can be taken to improve conditions in such settlements and reduce their adverse impact on the environment.

Reserves should be established surrounding settlements and extending for a few kilometers out from their limits and within which grazings, farming and fuel gathering are restricted. Such reserves must be well fenced on their boundaries and wherever they are traversed by roads. They should be regarded as areas affording regeneration of natural vegetation, but they may be subject to land treatment and planting where degradation is advanced.

Special measures will be required to check active physical degradation around settlements when it threatens urban land and gardens. It may be necessary, for example, to stabilize moving sands and to check gullies or fill them in.

Roads in and near settlements should be paved or otherwise improved. Traffic should be confined to roads by fencing.

Open areas inside settlements which form sources of dust nuisance or which retain stagnant water after rain should be brought under control. Grassing and planting of shelter belts may be required, but attention should be given to types of wind-stable ground cover which require little maintenance and consume little water, as for example gravel surfaces relieved by the planting of local trees and shrubs.

Adequate storm drainage should be provided to handle the runoff from rains which if infrequent are often intense when they come.

Services such as water supply, sanitation, waste disposal and street maintenance should not only meet general standards but should be reinforced to cope with the special stresses due to the desert environment.

Assistance and encouragement should be given to residents to improve conditions in and around their own homes. Insulating or screening materials might be provided or help given in the reconstruction of homes or in the establishment of gardens, shelters and shade belts.

If much can be done to improve the conditions of existing settlements, control must be exercised over their further growth.

Proposals to expand settlements or to establish new towns should incorporate environmental impact assessments which take into account the possibilities for desertification that such activities bring with them. The assessments should include estimates of future demand for water and energy and for land presently used for other purposes, and of the consequences of these projected demands. They must include estimates of requirements for waste disposal, sanitation and other services.

New housing and settlements should be designed to reduce stresses imposed by the desert environment, for example by the layout and orientation of houses, by screening, insulation and cooling devices and the provision of outdoor living areas, all planned to be compatible with local life styles. Roofs should be designed to catch and store stormwater and should be adaptable to the use of solar heaters. Settlements should incorporate shelters and the control of open spaces to reduce the threat of wind, dust and moving sand. Perimeter reserves and controlled recreation areas should be included as a normal part of urban plans.

Research should be encouraged into architectural and living problems in desert regions. Studies should be made of the use of solar energy at various scales for domestic needs and industry, of the use of wind energy in small installations, and of other alternative energy sources which can reduce the use of wood as fuel. Local materials should be studied for their use in construction. Progress can be made in improving insulation and cooling systems, including those employing solar power. Trees and shrubs should be examined for their suitability as protection and ornaments in deserts settlements. Research should continue on techniques for the desalination of water, on recycling water, and on the use of brackish water in sanitation and industry. Studies can result in improvements in subsurface water storage and the purification of water supplies. Methods of waste disposal can be more compatible with the arid environment.

Some control needs to be exercised over the relationships between settlements and their hinterlands. In recent decades, urban growth in and near deserts has been linked to out-migration from nearby rural areas. Since such migration will continue, it should be anticipated in plans for housing and community services. Urban development plans should form an integral part of regional development and resettlement schemes.

Urban development, with its demands for water, fuel, construction materials, land and labour, should not be carried out to the detriment of adjacent livelihood systems. The prior needs and rights of those systems should be protected from the environmental impact of planned settlement growth, and the siting and design of settlements should be influenced by such considerations. At the same time, rural people should be made aware of the possible advantages to them of nearby settlements, and they should be involved in planning new communities and preparing for the growth of established settlements.

In Conclusion

This survey of desertification contains many suggestions, both explicit and implicit, for combating the process and for reclaiming land that has suffered the ravages of degradation. Many of these suggestions appear as recommendations in the Plan of Action to Combat Desertification that will be submitted to the United Nations Conference on Desertification to be held in later summer of 1977.

Some suggestions call for additional research and an improved understanding of ways in which desertification operates and of methods for combating it. This is all to the good, as is any proposal that would make the task of land reclamation easier. But the fact is that most instances of desertification can be dealt with through knowledge and experience that are available right now. The Romans applied terracing to convert the North African littoral into the breadbasket of the Mediterranean. Good land-use practices transformed the Great American Desert into the wheat empire that it is today. The SCARP project in Pakistan has reclaimed 45 per cent of one million waterlogged acres of once-productive irrigated land.

The immense changes affecting the contemporary world have brought the problem of desertification into sharper focus than ever before, just as pressures on the sensitive dryland ecosystems are more intense than ever before. Desertification can be halted and ravaged land reclaimed in terms of what is known now. All that remains is the political will and determination to do it.

CURRENT INTERNATIONAL ACTIVITIES TO COMBAT DESERTIFICATION

Introduction

1. At its fifth session the Environment Co-ordination Board decided that its focal points should prepare a report on the implementation of paragraph 1 of General Assembly resolution 3337(XXIX). Through this resolution, the General Assembly decided that concerted international action to combat desertification was a priority responsibility for the whole of the United Nations system. The Environment Co-ordination Board considered that it could best serve the expectations of the General Assembly through a review of current international activities to combat desertification, and an analysis of the extent to which these activities are co-ordinated or concerted.

2. For many years, several organizations of the United Nations system, individually or jointly, have been engaged in or provided resources for activities related to arid and semi-arid lands, ranging from research and the dissemination of information to training and the application of existing knowledge. Present developments, however, in certain parts of the world, particularly the Sudano-Sahelian regions and adjacent areas of Africa, have served to stimulate interest in the interaction between the incidence of drought and the process of desertification, and to intensify concern about the impact of this interaction on man and on dryland eco-systems.

3. This concern is reflected in the large number of recent decisions and initiatives taken by various United Nations organizations. Among these may be mentioned General Assembly resolution 3054(XXVII) concerning, among other things, the search for a medium and long-term solution to the problems of desert encroachment in the countries bordering on the Sahara and other areas with similar geographical conditions; the UNDP Governing Council decision at its seventeenth session calling for action programmes corresponding to the medium and long-term implications of the drought affecting Africa and adjacent areas; the UNEP Governing Council decision 8(II) adopting proposals for an integrated research programme and other activities on arid and semi-arid lands; General Assembly resolution 3202 (S-VI) regarding the Programme of Action on the Establishment of a New International Economic Order which, among other things, called for concrete and speedy measures to arrest desertification; ECOSOC resolution 1874(LVII) on the strategy for transforming ecological conditions in the Sudano-Sahelian region; ECOSOC resolution 1878 (LVII) stressing the need for a well co-ordinated, system-wide attack on the drought problem in Africa; and ECOSOC resolution 1898(LVII) aimed at the preparation of a world programme of development research and application of science and technology to solve the special problems of the arid areas.

4. In response to a number of the decisions just mentioned, an inter-agency meeting was convened under the aegis of the Administrative

Committee on Co-ordination (ACC) in October 1974 (see CO-ORDINATION/R.1058) for the purpose of working out an appropriate allocation among the concerned organizations of the various tasks stemming from these decisions. Following the adoption of General Assembly resolution 3337(XXIX) on international co-operation to combat desertification, another interagency meeting was convened by the ACC in March 1975 (see CO-ORDINATION/R.1081) in order, chiefly, to prepare the ground for the work of the secretariat of the United Nations Conference on Desertification, envisaged in that resolution, and of the interagency task force which, under the same resolution, was later convened to assist that secretariat. The Conference, scheduled to be held 29 August - 9 September 1977, is now seen as a principal mechanism for co-ordinating current international activities to combat desertification and for starting new activities which, together with current activities, will constitute a concerted international programme of action against desertification and for the rational social and economic development of drought-prone areas.

Reviews of Desertification and Related Problems

5. In its resolution 1898(LVII), the Economic and Social Council requested the Secretary-General to convene an ad hoc interagency task force on the arid zones, which would identify the obstacles to development of arid and semi-arid zones, including social, economic, institutional, and other obstacles. The task force was also asked to prepare an inventory of current research and development actions and programmes with the view to preparing a world-wide research and development programme for the arid and semi-arid zones. The task force was convened under the auspices of UNESCO on 29 January to 2 February 1975. It adopted a report on obstacles to development (E/C.8/WG.1/3) which was reviewed by the Intergovernmental Working Group of the Committee on Science and Technology for Development (CSTD) and submitted in its final revised form to the full Committee in February 1976. The report has been issued by UNESCO.

6. Regarding the inventory of current research and development actions and programmes, the UNEP secretariat produced in late 1974 a comprehensive survey of activities related to arid and semi-arid lands and soil loss (UNEP/GC/30). This survey was part of the review of UNEP's priority subject area "Land, Water and Desertification". UNESCO is expected to convene a second meeting of the ad hoc interagency task force on arid lands to update and expand this survey to comply with the ECOSOC resolution.

7. The subsequent General Assembly resolution 3511(XXX) requested CSTD, with the assistance of the Advisory Committee on the Application of Science and Technology to Development (ACAST), to include in its programme of work on arid areas, in pursuance of ECOSOC resolution 1898(LVII), proposals to close the gaps in scientific knowledge and technologies concerning desertification. The Office for Science and Technology of UN/ESA, which serves both Committees, is preparing these proposals for submission to the Conference on Desertification.

8. The Conference secretariat has arranged for the preparation by consultants of scientific reviews of four components of the desertification problem: climatic change, ecological change, demographic, social, economic, and behavioural aspects, and technological aspects. These have been synthesized in an overview document for presentation to the Conference. In

addition, UNESCO has prepared, with UNDP financing, six case studies of desertification and efforts to combat it in selected areas of Chile, India, Iraq, Niger, Pakistan, and Tunisia. These studies, along with similar case studies to be contributed by the Governments of Australia, China, Iran, Israel, USA and USSR, have been synthesized for presentation to the Conference. Finally, a world map showing the extent of desertification has been prepared by FAO in co-operation with UNESCO and WMO. These and other preparations for the Conference are reported in UNEP/GC/67 and UNEP/GC/95.

Information, Monitoring, Research, and Training Activities

9. Regarding exchange of information on desertification and related topics, there are some recent developments within the United Nations system which may soon help meet the information needs of researchers, project administrators, and government decision-makers. FAO is developing AGRIS: International Information System for the Agricultural Sciences and Technology, which is an abstracting service providing summaries of research results, and the Current Agricultural Research Information System (CARIS), which will collect, organise and disseminate basic data on current research institutions, workers, programmes and activities in the fields of agriculture, animal production, forestry, inland fisheries, and food. UNEP is organizing the International Referral System (IRS), which will interconnect users of environmental information with appropriate sources of such information. Note should be taken of the Secretary-General's report (E/5807) on strengthening of United Nations information services in the natural resources field. This is a proposal that the Centre for Natural Resources, Energy and Transport (CNRET) of the UN/ESA, in close collaboration with the United Nations Statistical Office, serve as a focal point for collection, dissemination and documentation of information on mineral, energy and water resources.

10. Regarding monitoring of desertification and related features of arid and semi-arid areas, UNEP is planning the Global Environmental Monitoring System (GEMS), which will include a UNEP/FAO pilot project on monitoring of range and pasture ecosystems. In addition, the secretariat of the Conference on Desertification has arranged for two studies of the feasibility of regional co-operation in South America and southwestern Asia for monitoring of desertification and natural resources by satellite and aerial photography and ground surveys.

11. Regarding research on desertification and related topics, UNESCO's Arid Zone Programme, 1951-1965, produced some thirty publications which reviewed various physical, biological and human aspects of arid and semi-arid areas. An achievement of this programme has been the mobilization of scientists from many countries in the pursuit of a shared objective and the development of an interdisciplinary and integrated approach to the study of dryland problems. Hundreds of scientists from developing countries have been trained through fellowships and regional courses, and a number of permanent interdisciplinary research centres have been created or strengthened, including the Central Arid Zone Research Institute of Jodhpur, India, the Negev Research Institute of Beersheba, Israel, the Desert Research Institute of Cairo, Egypt, and the Natural Resources Research Institute of Abu Ghraib, Iraq.

12. UNESCO's longstanding activities on arid zone problems received further impetus with the launching in 1970 of the Man and the Biosphere Programme (MAB), an intergovernmental programme of scientific co-operation aimed at providing the scientific basis for the rational use of natural resources. It is primarily a programme of research and training. Two of the fourteen international project areas of MAB are of particular relevance to problems of desertification, namely Project 3 on the impacts of human activities and land use practices on grazing lands and Project 4 which is concerned with man's interrelations with irrigated systems in arid and semi-arid zones. In cooperation with UNEP and other collaborating international organizations, plans for a number of pilot research projects have been prepared, and a number of these field projects have now been launched by countries as part of MAB. These include systems analysis of Mediterranean desert ecosystems of northern Egypt, development of rangelands in southern central Tunisia and in the Wilaya of Saida in Algeria, a project on the perception of environment by Sahelian populations in northeastern Upper Volta, a UNEP/UNESCO project on integrated ecological development of arid lands (initially focused on the Acacia-dominated grazing ecosystems in the Mount Kulal region of Kenya), and a project in arid areas of the state of Durango, Mexico. In addition, a number of countries have designated arid areas within their territories as "biosphere reserves", natural areas protected for the role that they play in the conservation of plant and animal genetic material, in ecological research, and in education and training.

13. Following on the International Hydrological Decade, 1965-1974, UNESCO's International Hydrological Programme (IHP) places special emphasis on the integrated management of water resources and on the influence of human activities upon them. IAEA is also involved in hydrological research using radioactive isotopes for groundwater assessment, especially in checking the age of groundwater, its source, and rate of recharge. The Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture is planning isotope-aided studies on water and fertilizer use in semi-arid regions.

14. FAO, UNESCO and UNEP are jointly making a world assessment of soil degradation which could assist countries in controlling the loss of soils through erosion, salization, alkalinization, and desertification. A complementary activity is the FAO/UNESCO project, initiated in 1961, to prepare a World Soil Map.

15. A number of studies and experiments were initiated under UNESCO's Arid Zone Programme on the use of solar and wind energy in arid lands, where these sources are usually available and where it is important to avoid cutting wood for fire. These studies are currently receiving a new impetus in UNESCO as a consequence of the recent renewal of interest in the development of unconventional sources of energy.

16. Working groups and rapporteurs of the WMO Commissions for Atmospheric Sciences, for Agricultural Meteorology, for Special Applications of Meteorology and Climatology, and for Hydrology are concerned with subjects relevant to desertification, such as meteorology of semi-arid zones, climatic fluctuations, and meteorological aspects of land use, agriculture, soil degradation, sand dunes, and relationships between hydrological regimes and

drought. The ICSU/WMO Global Atmospheric Research Programme (GARP) has recently embarked upon activities in the field of climatic change. A long-term, project on research on modelling climate and climatic change is being developed. WMO and UNEP are also supporting agrometeorological and hydrological studies in the Sudano-Sahelian zone. The FAO/UNESCO/WMO Interagency Group on Agricultural Biometeorology, since its creation, has supervised agroclimatological surveys of arid and semi-arid areas in the Near East, the Sahel, East Africa, and South America which all provide information relevant to the desertification processes in these areas.

17. As far as both training and research are concerned, the UNDP/WMO project in the Sahel countries aimed at strengthening the national meteorological and hydrological services and at the establishment of a regional agrometeorological and hydrological centre is of particular importance. In the initial phase of this project, which is also supported by a number of donor countries, the training of meteorological and hydrological experts in these countries will greatly contribute to future research on and applications to the problems of desertification and drought occurrence in the Sahel.

18. Regarding the human and economic implications of desertification and drought, UNDRO is currently undertaking a World Survey of Disaster Damage, which will include information on the economic losses over the past fifteen years due to drought, famine, and desertification. UNDRO is also preparing, with UNEP financial support and in co-operation with WMO and UNESCO, a series of studies on the state of existing knowledge in disaster prevention and mitigation. Portions of the studies on hydrological, meteorological, volcanological, and land-use aspects concern directly or indirectly specific natural phenomena which can cause or contribute to drought and desertification.

19. The International Federation of Institutes for Advanced Studies (IFIAS) and UNEP are supporting a study, entitled "Drought and Man", which will examine the social, economic, political, and ethical consequences of drought. UNITAR, with UNEP support, has arranged for a study, accompanied by a symposium, on alternative economic strategies for the development of arid and semi-arid lands, as part of UNITAR's Project on the Future. Complementary to this study are two UNEP/UNCTAD research projects, one on the environmental component in the social evaluation and pricing of natural resources, the other on the impact of environmental issues on the foreign trade strategies of developing countries. FAO is preparing case studies on contemporary changes in agrarian structure with special reference to arid and semi-arid areas of the Near East and Africa. ILO has prepared case studies in India and Brazil as part of its development of emergency employment schemes under the World Employment Programme. WHO has undertaken surveys in collaboration with UNICEF and FAO to ascertain the health and nutrition situation in drought-stricken areas of Africa.

20. Several of the specialized agencies and bodies of the United Nations, especially UNDP and UNEP, are examining with the Sahelian Governments the prospects for establishing the Institut du Sahel (Sahelian Institute), the main objectives of which would be promotion

and co-ordination of research, dissemination of the findings, transfer and adaptation of technology, and training of research workers. This institute could serve as a prototype for regional research and development centres in other areas affected by desertification.

Application of Knowledge

21. During 1973, the Permanent Interstate Committee on Drought Control in the Sahel (CILSS) was constituted by representatives of Chad, Mali, Mauritania, Niger, Senegal and Upper Volta. They have since been joined by Cape Verde and Gambia and have established a secretariat in Ouagadougou. CILSS, with the support of the United Nations Sahelian Office, is becoming the principal intergovernmental co-ordinator for development projects in the region. As such, the United Nations and the specialized agencies active in the region are collaborating increasingly with CILSS.

22. In March 1976 the Club des Amis du Sahel was formed at a meeting in Dakar under the auspices of OECD and CILSS. The Club is sponsored jointly by the member countries of CILSS and a number of donor countries and organizations and is open to all Friends of the Sahel. Its purpose is to support measures taken by CILSS, to encourage co-operation among donors, and to provide a forum where the Sahelian States can explain their medium-term and long-term development policies and priorities and discuss them with donors.

23. In the Sudan, UNEP is helping to organize a meeting of donor countries and organizations to encourage and co-ordinate their financial support for a series of national projects for controlling desert encroachment.

24. The principal donors or lenders of financial support to national development programmes in arid and semi-arid areas, as elsewhere, are the economically developed countries, the World Bank (IBRD), and UNDP, through bilateral and multilateral projects for improvement of animal production and health, forestry, agriculture, land and water use, development planning and policy for natural resources, water development, health services, and relief activities. Regional banks and funds, such as the African Development Bank, the Arab Bank for Economic Development in Africa, the Arab Fund for Economic and Social Development, the Asian Development Bank, and the Inter-American Development Bank, are also financing projects in these sectors.

25. The World Food Programme (WFP) provides food assistance to foster the advancement of developing countries by using supplies of food as an investment in projects for economic and social development, including land development, reforestation, and soil conservation.

26. A large proportion of projects applying existing knowledge in the field are executed by the members of the United Nations system with funds provided by UNDP. Approximately three-quarters of the resources devoted to arid and semi-arid areas are spent on application of existing knowledge in numerous local projects, mainly in Africa. The principal executing agencies and bodies of the United Nations are FAO, ILO, UNICEF, UN/OTC, WHO, and WMO. As many of their projects are listed in the UNEP review on land, water and desertification (UNEP/GC/30), only the general orientation of the agency programmes will be reviewed here.

27. FAO activities relating to desertification principally involve animal production (including the sub-programmes on genetic resources and feed resources, meat and milk development, and prevention or control of animal diseases and pests) and forestry (including sand dune fixation, shelter belts, watershed management, and wildlife management). One specific activity directly connected with pastoral areas around desert lands is work started in 1970 on the improvement of nomadic and transhumant animal production systems.

28. In co-operation with UNEP, FAO is about to launch a programme on the Ecological Management of Arid and Semi-Arid Rangelands in Africa and the Near and Middle East (EMASAR). A permanent secretariat is to promote and assist national programmes and regional activities related to range management and to facilitate concerted action at sub-regional, regional, and global levels. The programme will involve surveying and monitoring, education and training, advisory services, and development programmes.

29. Complementary to FAO activities are three studies of the feasibility of transnational co-operation in the production and marketing of livestock in the Sahel and the establishment of a stabilization zone or green belt of naturally-regenerated or planted vegetation on the northern and southern boundaries of the Sahara. These studies are sponsored by the secretariat of the United Nations Conference on Desertification in co-operation with FAO and other organizations with financial assistance from UNDP.

30. The United Nations, through the Water Resources Branch of CNRET/ESA, is sponsoring water development projects in arid and semi-arid areas in all continents, with special attention paid to the Sahel region and the Middle East. These projects include the integrated development of scarce water resources, the training of local teams in the production of additional water points, and the strengthening of the water-related government services. UN/ESA has played a significant role in the development of fractured-compact rock aquifers, which can be found in large areas of the arid zones and very often provide the sole source of water, in the development of artificial recharge under arid conditions, and in planning water use in arid areas, through mathematical modelling and administrative/legal reform. The rational use of water in arid and semi-arid areas is one of the subjects discussed by the United Nations Water Conference, organized by CNRET/ESA. In addition, the secretariat of the United Nations Conference on Desertification has commissioned a study of the feasibility of regional co-operation in the use of shared aquifers in northeastern Africa and the Arabian Peninsula. Because of the overlap in their areas of concern, the secretariats of these two conferences have co-ordinated their preparatory activities.

31. WHO and UNICEF have together defined the framework for an action programme for medium-term and long-term developments in health. Emphasis is placed on four adverse effects of drought and desertification: malnutrition; outbreaks of communicable diseases; environmental health problems; and the preparation of health manpower to provide the necessary health services. The WHO Regional Office for Africa is giving particular attention to improving the functioning of the existing structures and to adapting new structures to the solution of problems specific to the areas concerned. Accordingly, WHO is exploring the possibilities for health

development in the Sahelian region following the primary health concept, which places maximum reliance on available community manpower resources.

32. WMO is providing short-term experts to developing countries to assist their agrometeorological services to aid food production. It is expected that about ten countries within the arid and semi-arid zones of the world will be provided with such support during 1976-1978.

33. ILO is carrying out, in close liaison with CILSS, technical co-operation activities concerned with rural development, quick employment generating schemes, vocational training, and rehabilitation, which contribute to recovery and resettlement programmes for people afflicted by the drought in the Sahel.

34. The United Nations Conference on Desertification will produce a world plan of action to combat desertification. A draft of this plan of action has been reviewed by government-nominated experts in four regional preparatory meetings sponsored by the Conference secretariat and the United Nations regional commissions in consultation with the Organization for African Unity. While current activities are numerous and relatively well co-ordinated, new action programmes are needed to fill gaps in the present research and development effort. The Conference provides an opportunity to identify and fill these gaps and to improve co-ordination of national, regional, and global action to combat desertification.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

PLAN OF ACTION TO COMBAT DESERTIFICATION
SECOND PRELIMINARY DRAFT

PREPARED ON THE OCCASION OF THE
REGIONAL PREPARATORY MEETINGS
FOR THE CONFERENCE

Corrigendum

Paragraphs 73 and 74

In lines 5 and 6 of paragraph 73 and line 1 of paragraph 74, change "International Desertification Research Council" to "International Advisory Council on Desertification Research".

In lines 4 and 5 of paragraph 74, delete "The functions of the Council would include" and insert a comma after "UNEP", followed by the words "and would advise the Chairman of the Environment Co-ordination Board on:".

In line 1 of paragraph 74 (c), delete "Advising on means of", thus leaving "Supporting" as first word of the sentence.

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UNITED NATIONS CONFERENCE ON DESERTIFICATION

PLAN OF ACTION TO COMBAT DESERTIFICATION
SECOND PRELIMINARY DRAFT

ITEM 5

OF

THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETINGS FOR

THE AMERICAS
Santiago, Chile 23 - 26 February 1977

Secretariat of the United Nations
Conference on Desertification,
P.O. Box 30552,
NAIROBI.

January 1977

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UNITED NATIONS CONFERENCE ON DESERTIFICATION

PLAN OF ACTION TO COMBAT DESERTIFICATION
SECOND PRELIMINARY DRAFT

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ITEM 5

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THE AMERICAS
Santiago, Chile 23 - 26 February 1977

AFRICA SOUTH OF THE SAHARA
12 - 16 April 1977

THE MEDITERRANEAN AREA
Algarve, Portugal 29 March - 2 April 1977

ASIA AND THE PACIFIC
New Delhi, India 19 - 23 April 1977

Secretariat of the United Nations
Conference on Desertification,
P.O. Box 30552,
NAIROBI.

January 1977

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INTRODUCTORY NOTE BY THE SECRETARIAT OF THE UNITED NATIONS CONFERENCE ON DESERTIFICATION

i. In accordance with the provisions of General Assembly resolution 3337 (XXIX) on international co-operation to combat desertification a draft Plan of Action to Combat Desertification is to be presented to the United Nations Conference on Desertification (29 August - 9 September 1977), for consideration and adoption. The present draft of the Plan of Action has been prepared for consideration by the four regional preparatory meetings for the Conference. Together with the reports on the regional consultations, this draft will also be presented for review at the Fifth Session of the Governing Council of the United Nations Environment Programme acting in its capacity as the intergovernmental preparatory body for the Conference.

ii. A preliminary draft was circulated for comment in August 1976 to Governments, the United Nations system, intergovernmental organizations, research institutions and other bodies, and the panel of senior consultants, appointed by the Executive Director of the United Nations Environment Programme, to advise the Secretariat of the Conference. The present draft has been elaborated, taking into account the comments and suggestions received, and with the assistance of the advisory group of experts on the Plan of Action.

iii. The text remains preliminary in both its scope and content. Further drafts will be prepared in the light of discussions at the regional meetings and at the fifth session of the Governing Council of UNEP, acting in its capacity as the intergovernmental preparatory body for the desertification conference. The final draft is to be issued on 1 June 1977 as one of the principal documents for the Conference. It is expected that these later versions of the Plan will include an indication of the order of magnitude of the funds required for the regional and international action in the immediate period of the Plan's implementation; i.e., from 1978 to 1984.

iv. The present text has been written taking into account the consolidated action recommendations for the United Nations Water Conference (E/C.7/L.52). It has also been prepared in the light of discussions during the twenty-second session of the Advisory Committee on the Application of Science and Technology to Development (E/AC.52/XXII/CRP.17). The Plan, because of the timing of the preparation of the present draft, only partly reflects the findings and recommendations of the component reviews, the overview, the case studies and the feasibility studies. The Plan in its subsequent draft will take full account of these and other preparatory material for the Conference, as well as the discussion at the regional preparatory meetings.

CHAPTER I. ORIGIN AND SCOPE OF THE PLAN

1. More than one-third of the earth's land area is arid. Much of it has become desert since the dawn of civilization, and many vulnerable areas are even now being turned into desert because of man's actions. This process has intensified during recent decades. The spread of desert conditions threatens the future of 680 million people, or that 16 per cent of the world's population who live in the drylands. In the past half century, on the southern edge of the Sahara alone, as much as 650,000 square kilometres of land once suitable for agriculture and grazing, has become desert. The Sahelian drought of 1968-1973 and its tragic effect on the peoples of that region drew world attention to chronic problems of human survival and development on the desert margins.

2. In conformance with the Charter of the United Nations, a number of resolutions by the United Nations General Assembly have addressed these problems. The first All-African Seminar on the Human Environment, convened in August 1971 under the auspices of the Economic Commission for Africa (ECA), made specific recommendations for steps to be taken to combat the spread of deserts in Africa. At the third session of the ECA Conference of Ministers, Resolution 264 (XII) on desertification drew attention to this menace and urged that ECA take steps in collaboration with the international community to seek solutions to the problems. General Assembly Resolution 3202 (S-VI) of 1 May 1974 recommended that the international community urgently take concrete measures to stem the spread of deserts and assist the economic development of affected areas. Economic and Social Council Resolution 1878 (LVIII) of 16 July 1974 requested all the concerned organizations of the United Nations system to pursue a broad attack on the drought problem. Decisions of the Governing Councils of the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP) emphasized the need to undertake studies on the extent of drought, and to draw up appropriate action programmes against the spread of deserts.

3. The General Assembly then decided, by Resolution 3337 (XXIX) of 17 December 1974, to initiate concerted international action to combat the spread of desert conditions, or "desertification" as it is now called. To give impetus to international action, the General Assembly decided to convene a United Nations Conference on Desertification, now scheduled for 29 August - 9 September 1977, which would produce an effective, comprehensive and co-ordinated Plan of Action to Combat Desertification.

4. Deserts are areas of sparse or absent vegetation and low biological productivity primarily due to deficient rainfall. Desertification is seen as the extension or intensification of such conditions. In preparing for the Conference, attention was focused on tropical, subtropical and temperate drylands. The Plan of Action covers areas where desertification is occurring now and others vulnerable to future desertification, including arid, semi-arid and sub-humid areas. The distribution and relative intensity of desertification problems are shown on the Desertification Map of the World (A/CONF/74/).

5. Recognizing that the physical and biological effects of desertification are important to the world community mainly because of their impact

on human beings, the Plan of Action focuses on the problems of people affected by desertification.

6. Desertification is an aspect of the widespread deterioration of ecosystems under the combined pressures of adverse and fluctuating climate and excessive or ill-advised exploitation. Such exploitation has diminished or destroyed the productive potential of food and fibre-producing ecosystems at a time when increased productivity is needed to support growing populations in quest of development. Important factors in modern society - the struggle for development, population growth and change and the effort to increase food production - interlock in a network of cause and effect. Progress in development, planned population growth, and improvements in food production must therefore be dealt with together. The deterioration of productive ecosystems is an obvious and serious threat to human progress. In general, the quest for ever greater productivity has intensified exploitation and has carried disturbance by man into less productive and more fragile lands. Overexploitation gives rise to degradation of vegetation, soil and water, the three elements which serve as the foundation for development in many nations. Desertification is a self-accelerating process, feeding on itself, and as it advances, rehabilitation costs rise exponentially. In exceptionally fragile ecosystems, such as those on the desert margins, the loss of productivity through the degradation of soil can easily become irreversible, permanently reducing their capacity to support human life. Action to combat desertification is required urgently before the cost factor rises beyond practical possibility or before the opportunity to act is lost forever.

7. This Plan of Action presents a set of recommendations for initiating and sustaining a co-operative effort on the scale required to combat desertification.

CHAPTER II. OBJECTIVES AND PRINCIPLES

8. The immediate goal of the Plan of Action to Combat Desertification is to arrest the processes of desertification and, where possible, to reclaim desertified land for productive use. The ultimate objective is to sustain the productivity of arid, semi-arid and sub-humid areas vulnerable to desertification. A campaign against desertification should, therefore, take its place as a priority among efforts to achieve optimum a sustained production. For developing countries affected by increas ng ar y, the implementation of this Plan of Action implies m than campaign against desertification. It is an essential part of the broad process of development.

9. Desertification is not a problem susceptible to quick solutions. It calls for continuous assessment and long-term planning and management at all levels, supported by international co-operation. Such programmes, even when long-term, should be started without delay. Since it is easier to prevent desertification than to reclaim desertified land, delay in the implementation of preventive measures can only increase the ultimate cost and decrease the chances for success. In many cases, technical solutions are available now. But, even with sufficient time, investment, and labour, their eventual implementation may be prevented by social, legal, and sometimes institutional factors.

10. Given the interdependence of the development process, population change and agricultural productivity, it follows that the effects of desertification on productive ecosystems can best be ameliorated if action is taken in all three sectors. In other words, efforts to combat desertification must be part of a broad programme for promoting social and economic progress. The United Nations has expressed a common aspiration to improve the quality of life for all people, especially in developing countries. This aspiration manifests itself in the Charter of the United Nations and in international declarations, decisions and recommendations, particularly of the past decade, especially in the Declaration for the Establishment of a New International Economic Order and the programme of action to achieve it, in the Charter of Economic Rights and Duties of States, in the International Development Strategy for the Second United Nations Development Decade, in the Declaration on the Human Environment and in the action plans of the United Nations Conferences on the Human Environment, on Science and Technology, Population, Food, Women, Trade and Development and Human Settlements. These represent steps taken by the international community toward the formulation of essential programmes for development in its broadest sense. To be successful, the effort to combat desertification must be seen as an integral element in this larger effort toward social and economic advancement.

11. Desertification frequently appears as the deterioration of land, water and other natural resources under extreme climatic conditions. Degradation implies that activities undertaken in an areas have been unsuitable, either in degree or in kind, to the resources and the conditions that prevail there. Such activities may have been pursued

because alternatives were lacking or because of attempts to maximize short-term gain at the expense of long-term productivity. While solutions probably rest ultimately in education, social and economic advancement and the adjustment of population growth to growth in resources, the proximate solution centres on improved land use. This involves three elements: a) an inventory of local land use capabilities, b) a determination of which uses are desirable in terms of land-use capabilities and socio-economic goals and constraints, and c) a system for implementing the resulting plan for the proper exploitation and protection of natural resources.

12. Social problems in land-use management are a principal concern of this Plan of Action to Combat Desertification. As the management of natural resources is a critical component of any strategy for physical, social, or economic development, the adoption of improved policies for the management of natural resources is essential to all ecosystems if their productivity is to be maintained. The recommendations in this Plan of Action for assessment and management of natural resources have general application but, in the context of this plan, they focus on areas vulnerable to desertification and on those desertified areas that admit to a degree of recovery.

13. The causes of desertification vary among the affected regions of the world owing to differences in their ecological characteristics and their social and economic structures and aspirations. Each region may require a distinctive approach to desertification problems. With natural resource management as its primary concern, this Plan of Action recommends methods for setting priorities for action against desertification, but it leaves the actual determination of priorities to Governments. There are, however, desertification problems which cross national boundaries, and the Plan of Action aims at strengthening regional and international capacities to deal with such transnational problems and to provide effective international co-operation when requested.

14. Action against desertification should be supported by goal-oriented research. This calls for the selection of those subjects on which research is still needed and of centres in affected countries that should be strengthened and supported to carry out the research required. This in turn necessitates an international co-operative research effort inviting exchange and advisory visits among centres and consultations to review progress and advise on further work. While much of this may be seen as applied research, some basic research may also be envisaged.

15. The basic principles guiding this Plan of Action are these:

(a) All action shall be consistent with the provisions of the Charter of the United Nations.

(b) The plan is to be carried out as an effective, comprehensive and co-ordinated action programme against desertification, including the building up of indigenous scientific and technological capacities in the areas concerned.

(c) All measures are to be primarily directed toward the well-being and development of the peoples affected by or vulnerable to desertification.

(d) Efforts should be consistent with and, where practicable, form part of wider programmes for advancing economic and social progress.

(e) Implementation is based on the recognition of cultural and ecological variety in the vulnerable areas, and the overriding need for a sensitive and flexible response.

(f) A central theme will be the immediate adaptation and application of existing knowledge.

(g) There is, however, the need for additional research to clarify a number of fundamental problems for the solution of which the requisite scientific knowledge is not yet available.

(h) Additional research should be consistent with strengthening the scientific and technological capacity of the affected areas.

(i) Improved land use, calling for assessment and planning, is a key to success in combatting desertification.

(j) Improved land use should recognize the inevitability of periodic drought in drylands and their generally low agricultural potential.

(k) Implementation calls for a concentration of the resources of the United Nations systems in launching this Plan of Action and in carrying out an integrated and worldwide programme of development research and application of science and technology to solve the special problems of desertification.

(l) Land management should take into account a number of ecological principles:

(i) units of land need to be managed as wholes (e.g. an entire watershed, the total of plant and animal communities, an area viewed as a complex of microtopographies);

(ii) the use of drylands should be carefully timed to conform with fluctuations in climatic conditions;

(iii) the use of land should be carefully allocated so as to give maximum sustained productivity; its use must be fitted to its capabilities.

(m) While populations currently affected by desertification urgently require short-term relief measures, long-term amelioration should not be delayed, since the cost of prevention is less than the cure.

(n) Attention should be given to the assessment of secondary environmental problems which may be triggered by measures intended to remedy a desertification situation, as well as the effects of development activities undertaken outside affected areas.

16. The implementation of the Plan of Action to Combat Desertification is expected to be carried out by Governments through their national institutions, with the support, when requested, of international, bilateral or private programmes.

CHAPTER III. RECOMMENDATIONS FOR ACTION

17. The following set of recommendations is proposed for co-operative national and international action to combat desertification. Taken alone no single recommendation would be successful against the broad problem of desertification. An integrated complex of measures is the only way to arrest desertification and restore the productivity of areas already desertified. Integration means that each recommendation is linked in some way to other recommendations. Ideally, all the recommended actions should be implemented together, but unfortunately many countries do not have sufficient resources to do this. Hard choices must be made in the allocation of scarce resources to action programmes. National priorities must be established before national and international financial and technical resources are committed to action programmes.

18. It is recognized that the countries affected or likely to be affected by desertification are at different stages with respect to their appreciation of desertification problems and their ability to cope with them. Depending on the level of national awareness and on the kinds of action already taken, countries will follow a certain sequence in their efforts to combat desertification, entering the campaign at an appropriate stage. The sequence of stages might be as follows:

(a) First, establish whether desertification exists, and if so, define its magnitude and impact as follows:-

(i) determine the criteria for identifying and assessing desertification;

(ii) establish a national body for assessment and monitoring of desertification;

(iii) assess the problem on the basis of the criteria and techniques adopted;

(b) If a significant problem does exist, then:

(i) set up a system to monitor it;

(ii) draw up and implement programmes as outlined in the Plan of Action to Combat Desertification.

(c) Where remedial programmes have already been started:

(i) monitor the progress of the programmes, assesing their usefulness;

(ii) disseminate information on them to the international community.

For countries at an advanced stage, the second step might serve as a convenient point of entry, whereas countries that are still more advanced may wish to enter at the third step, or they may consider their current activities in the light of the recommendations in the Plan of Action.

19. Target dates for the implementation of recommended actions are proposed in the Plan. It is not always possible to specify timetables in such a broad programme, especially when long-term actions are required. Nevertheless, whenever appropriate, target dates are suggested. The goal is to implement the Plan of Action by the year 2000, starting in 1978.

20. Given the premise that desertification is basically a problem of the misuse of natural resources under extreme climatic conditions, and bearing in mind that the actual situation in the majority of areas affected by desertification is not fully assessed, the proposals start with arrangements for assessment and planning. They then proceed to specific recommendations for improved land management and to action against desertification, concluding with supporting measures, international co-operation and comments on financing the plan.

A. ASSESSMENT AND PLANNING

Recommendation 1

21. Before undertaking any action against desertification, it is desirable to assess and evaluate desertification in the local situation, its magnitude and extent, its causes and effects. It is necessary to know exactly what parts of the country are affected or vulnerable.

> It is recommended that desertification be assessed and evaluated as it affects both land and people in countries experiencing or likely to experience it.

22. To implement this recommendation, national action is desirable. A system of survey and monitoring should be established or strengthened to assemble information on dryland resources and populations and to carry out continuous monitoring of dryland dynamics, including the human condition. The assembly and evaluation of information should be a continuous process providing a feedback mechanism for national planning and action. To carry this out, national action should be considered to:

(a) Improve networks of meteorological and hydrological stations in areas subject to desertification in order to allow closer and more continuous monitoring and assessment of climatic and hydrologic conditions as they relate to the desertification process. In most of the areas of the world where desertification takes place such networks are deficient. They could be considerably improved through appropriate action by national meteorological and hydrological services, with the assistance of the World Meteorological Organization (WMO) if requested. In areas of sparse

population where staffing of stations may be difficult the use of automatic observing stations could be considered. National meteorological and hydrological services should provide continuous assessments of conditions based on these data.

(b) Monitor desertification by observing atmospheric processes, the state of vegetation and soil cover, dust transport, the shifting of sand dunes, the distribution, migration and abundance of wildlife, the condition of livestock, the phenology of crops, crop yields, and changes in irrigated lands.

(c) Compile desertification maps and see that they are revised through periodic resurveys using modern techniques, including remote sensing.

(d) Monitor socio-economic, demographic and health conditions of population affected or threatened, by strengthening census procedures where necessary. Such monitoring should address these variables and indicators:

(i) Population: size, density, age and sex composition, rate of growth, migration patterns;

(ii) Human and environmental health: incidence and prevalence of malnutrition and disease, identification of psychological factors affecting health, the physical and psychological development of children;

(iii) Food: its availability, eating habits and food taboos, status of nutrition education;

(iv) Human settlements: housing, drinking water and sewage disposal, sanitation, fuel and electricity;

(v) Education: literacy rate, mean educational level;

(vi) Sociocultural patterns: national or tribal composition, income and standard of living, social impediments to advancement, extent and impact of social welfare activities;

(vii) Man as a land user: how land is used and worked, what obstacles exist to carrying out the changes called for by measures to combat desertification.

23. The recommendation also implies regional action, such as:

(a) The implementation of regional schemes suggested by studies on the feasibility of regional or transnational co-operation in the monitoring of desert processes, including the use of satellite imagery (1978-1980).

(b) The organization of a system for the exchange of information gained from monitoring among the countries of the regions concerned (1978-79).

24. Finally, the recommendation calls for international action to:

(a) Make available to Governments on request, a consulting service for assistance in organizing systems of desertification monitoring (1978-80).

(b) Provide technical assistance to Governments on request, for the establishment, expansion and improvement of networks of meteorological and hydrological stations in areas subject to desertification (1978-82).

(c) Compile, publish and distribute a desertification atlas containing maps at a scale adequate to show detail. Such an atlas should be periodically revised (1978-82).

(d) Promote the establishment of dryland biosphere reserves that could preserve genetic diversity and provide a baseline for monitoring (1978-82).

Recommendation 2

25. Introduction of improved and effective land management in areas subject to desertification involves a broad range of social, economic, institutional, legislative, technical and other measures. Among various criteria which might guide the proposed changes the most important are: desertification hazards as defined by climate, the availability of water, land capability, and other environmental constraints, and by population and its pressures, social and economic goals and constraints, cultural and behavioural patterns, health conditions, location and relationships with other areas. The wide diversity of socio-economic structures and environmental conditions in dryland regions demands flexibility and suggests that blanket proposals are unsuitable. Each dryland area has established its own land-use practices on the basis of local conditions and aspirations, and these constitute the starting point for proposed changes. At the same time, some general principles of land-use planning and management, as well as of land-use surveys, might be recommended internationally on the basis of existing knowledge. Whereas the present Plan of Action is concerned only with areas affected or likely to be affected by desertification, changes in land-use management proposed for those areas should be consistent with broader national or regional development plans.

It is recommended that in areas affected or likely to be affected by desertification, changes in land-use practices based on ecologically and economically sound principles should be introduced in conformance with social equity and geared to economic and social development.

26. To implement this recommendation national action is desirable to:

(a) Strengthen national capabilities in land-use planning and direct them towards problems of desertification. Many nations have national or (in federal systems) state/provincial economic planning commissions. It is logical for land-use planning to be one of the major responsibilities of high-level planning groups concerned with national or state/provincial development. Where such a planning group does not exist, it should be established at a high level of government, with authority to formulate policy and plans and to guide the implementation of those plans. In carrying out such action, these factors should receive consideration:

(i) Local-level planning should be encouraged whenever possible or appropriate. It is also important to call upon all available talent to participate in the planning process.

(ii) Land-use planners should have access to expertise in law, economics, demography, sociology, urban planning, ecology, geography, agricultural sciences, hydrology, climatology, remote sensing, statistics, and cartography. However, the planner's primary training should be in the theory and techniques of assessment, planning and management of human and natural resources. Where such training is not locally available arrangements should be made to train planners elsewhere.

(iii) The land-use planning group should be supported by a natural resources survey and monitoring programme.

(iv) However, action against desertification should not wait on the formation of a unit composed of specialists in all pertinent fields of land-use planning. When desertification problems are apparent, a start should be made by calling upon the best talent and information available for the formulation and implementation of plans to combat desertification, which are consistent with national goals.

(b) Inform the public of the consequences of the misuse of land and other natural resources and of the need for land-use

planning and management so as to ensure general public awareness of and participation in planning and action to combat desertification. Successful land-use planning and management depends on public co-operation. Plans or actions to change land use should take account of the wishes, needs, wisdom, and aspirations of the people for whose benefit the plan is ultimately intended. This can be done only by involving the people in planning and implementation, by consulting them and obtaining their agreement. To ensure public participation in planning and action to combat desertification consideration should be given to:

(i) the development and operation of a system of community education and public discussion on problems of desertification and measures to combat it, using existing facilities for public information, extension services and education;

(ii) the establishment or strengthening of facilities for public participation in land-use planning and management;

(iii) programmes of education in the use of land and other natural resources in rural schools, training centres and extension services, as well as in appropriate institutes and universities.

(c) Survey natural resources and the human condition in areas affected or likely to be affected by desertification. To be realistic, land-use plans must be based on accurate data. To provide control for data collection, the social and environmental objectives for an area must be precisely defined, thus producing a frame of reference for the survey work. Considerable information is already available for most areas of the world. The first task of a land-use planning group and its associated survey programme is to assemble and analyse this current information. The survey should then be designed to fill gaps in existing information and to update it through continuous surveying or monitoring. A land-use plan must be flexible enough to accommodate changes in the area covered, as revealed by monitoring.

(d) Formulate a land-use plan for an area small enough to be managed effectively within the resources immediately available. This can serve as a pilot area for testing plans, training managers and correcting planning errors. Out of this will arise a comprehensive land-use plan embracing a broad area. At the heart of land-use policy is the difficult determination of what people realistically hope to achieve with the resources at their disposal. Once a relatively complete inventory of natural resources and the human condition is available, the land-use planning group will identify the management options for each section of the area within its purview. Management options concern the types and intensity of use which are physically and

biologically appropriate to the resources of the section. The planners will choose from among these options the use which is most consistent with local nutritional needs and the socio-economic goals and constraints of the people living within the jurisdiction. The codification of these goals and constraints in relation to land-use constitutes a land-use policy. A comprehensive land-use plan would assign all sections of the area to particular uses, such as crops, livestock, game ranching, forests, recreation, mining, industry, roads and urbanization.

(i) Initially at least, land-use planning may be imprecise, given the size of the areas concerned, the absence of previous plans and limitations in financial and technical support. These rough preliminary plans can be elaborated and specified later as survey and monitoring proceed. Errors will undoubtedly be made, but action should not be deferred for fear of making mistakes.

(ii) Repeated evaluations and revisions of the land-use should be anticipated. The implementation of land-use plans should allow for continuing evaluation of the real impact of the project socially, economically and environmentally, and authorities should be prepared to learn from initial mistakes and to correct them.

(iii) Where the planners determine that a section of land has become unsuitable for human activities, they should propose complete protection, or a use which promotes natural recovery. This is particularly important in areas recently subject to severe degradation under the impact of human activities. Such areas may recover and be useful in the future if they are completely protected for a prescribed period.

(e) Develop procedures for implementing a comprehensive land-use plan. A comprehensive land-use plan specifies the preferred use for each section of the area covered, but the current or intended use of the section is not always the same as that in the plan. The problem of enforcing or implementing the plan is the problem of changing a current or intended use to correspond with what is recommended in the plan.

(i) A process should be established by legislative action to resolve national, regional or local conflicts among competing users and uses of land. This process will involve compensation to landowners and users who suffer economic and personal hardships from the required changes in

land use. It may also involve a system of incentives and penalties, such as grants-in-aid and differential taxation.

(ii) Systems of taxation, land tenure, water and mineral rights, agricultural credit, insurance, marketing, and transportation should be reviewed to ensure that they will encourage compliance with the comprehensive plan. Legislation relevant to exploitation and protection of natural resources should be reviewed and when necessary revised or supplemented to ensure consistency with the plan.

(iii) There are many possible enforcement or implementation schemes. Research and analysis are required to determine the best scheme for a particular country or province/state. Pilot projects that demonstrate the implications of a proposed land-use plan are an essential preliminary to large-scale efforts.

27. This recommendation also implies regional and international action to:

(a) Organize the training of land-use planners at international training centres (1978-85).

(b) Strengthen the African Institute for Economic Development and Planning (IDEP) for the international training of land-use planners (1978-82).

(c) Strengthen the natural and human resources survey units in the countries concerned, upon their request (1978-80).

(d) Organize pilot projects for the implementation of comprehensive land-use plans in each of five major regions affected by or vulnerable to desertification in co-operation with or in addition to national pilot projects (Sudano-Sahel, Northernmost Africa, West Asia, South Asia, Latin America; 1978-85).

(e) Organize short-term training courses on the implementation of comprehensive land-use plans for extension officers of the countries concerned.

(f) Make available to Governments, on request, a consulting service on land-use planning (1978-85).

(g) Work out and distribute to Governments, on request, a methodology for land-use planning (1978-79).

(h) Organize the training of survey specialists at existing international training centres (1978-82).

(i) Develop and distribute to Governments, on request, educational programmes on the dryland environment and desertification for inclusion in the curricula of institutes, training centres and universities and of rural schools (1978-79).

(j) Develop and distribute to Governments, on request, radio and television programmes on the dryland environment and desertification (1978).

(k) Produce and distribute to Governments, on request, leaflets or booklets, in the languages of the countries concerned, on the dryland environment and desertification for mass education programmes (1978-79).

(l) Make available to Governments, on request, a consulting service for national educational campaigns on desertification (1978-79).

(m) Undertake comparative studies on existing laws and institutions concerned with the use of natural resources, including land, and develop guidelines for legislation (1978-80).

B. POPULATION AND HEALTH

Recommendation 3

28. Present rates of population growth are unprecedented in human history. Population growth intensifies pressures on the drylands by increasing the number of people who live in them - farmers especially and to a lesser extent nomadic pastoralists - and by increasing global food requirements, already on the rise because of rising living standards and heightened expectations. At the same time, population growth is accompanied by massive migrations from rural areas to the cities. In excessive proportions, rural migrants tend to come from the most active, working-age groups, creating the paradox of labour shortages in rural areas in the midst of population increase. Labour shortages, in turn, have contributed to the deterioration of agricultural works and have thus served as a cause of desertification. At the same time, waves of rural migrants have compounded the problems of cities, often overcrowded to begin with and unequipped to receive the migrants and provide them employment and the basic amenities of life. Demographic policies designed to resolve or ameliorate such problems, should be seen as a natural and necessary corollary to policies directed toward improved land use.

It is recommended that countries should adopt demographic policies that will support programmes for improving land use, giving priority to the maintenance of an adequate rural labour force and to the resettlement of those migrating from rural to urban areas so as to minimize economic and psychosocial distress.

reduce rates of morbidity and mortality among both mothers and children, in conformance with the recommendations of the World Population Conference.

(b) Provide dryland peoples with primary family health care, including attention to nutrition and the spread of communicable disease. The dryland situation may require innovative methods for the delivery of primary health care, possibly including the use of mobile health units or "barefoot doctors".

35. This recommendation also implies international action, including that of non-governmental organizations, to provide advisory services to Governments, on request, on family planning and family health and to provide technical and financial support to programmes designed to deliver health care to peoples living in drylands.

C. WATER, LAND AND LIVELIHOODS

Recommendation 5

36. Water is the main factor limiting production and settlement in the drylands, and lack of water or its inefficient use are fundamental causes of many desertification problems. Improved water supplies, reduction in water losses, more efficient use of water and the development of new water resources are called for in many of the measures proposed to combat desertification.

It is recommended that efficient and environmentally sound water management and development be introduced as part of measures to combat desertification.

(This recommendation may be redrafted following the United Nations Water Conference in March, 1977).

37. To implement this recommendation national action should be considered to:

(a) Improve data on the quantity and quality of available water, through:

(i) periodic assessments of surface and ground water, preferably in terms of the water balance;

(ii) expanding and extending the network of meteorological and hydrological stations, and strengthening the organizations responsible for the collection and storage of data;

(iii) promoting the development and use of automatic recording instruments for remote stations;

(iv) developing the application of remote sensing in monitoring water supplies.

(b) Develop schemes of water management, preferably as part of national policy, to secure and integrate projected needs for domestic use, agriculture, livestock, industry and other uses.

(c) Promote the efficient use of water generally by developing and adopting appropriate technologies and policies, including water use in public facilities such as sanitation and waste disposal.

(d) Provide adequate domestic water supplies, free from contamination.

(e) Improve the supply and quality of surface water and its management, through:

(i) catchment management and the revegetation of watersheds, in conjunction with measures to reduce flood hazards and siltation;

(ii) establishing local water harvesting schemes;

(iii) promoting the construction of small earth reservoirs;

(iv) reducing reservoir losses through seepage and evaporation;

(v) improved means of water distribution, including the use of polyvinylchloride pipes and channels and linings made from local materials;

(f) Promote measures to improve the supply and quality of groundwater and its management, through:

(i) controlling the development and siting of wells and pumps;

(ii) improved maintenance of wells and pumps;

(iii) continuous monitoring of groundwater level and quality as part of managed use;

(iv) preventing groundwater pollution, including the intrusion of saline groundwater into aquifers;

(v) the use of solar and wind energy for pumping;

(vi) the promotion of schemes for groundwater recharge and the subsurface storage and purification of water.

(g) Introduce available technologies for water recycling, the use of brackish water, desalination and purification.

(h) Promote research into weather modification, evaporation suppression, and the application of systems analysis to water resource planning and management in drylands.

(i) Launch general campaigns for education in efficient and responsible water use, using public information services and seeking community participation through appropriate organizations.

38. This recommendation also implies regional action to develop water resources for rational use within regional economies, as suggested by the feasibility study on transnational co-operation in the shared use and management of large aquifers in North Africa and the Arabian Peninsula (1978-85).

39. Finally, this recommendation implies international action to:

(a) Organize regional training courses on water management in local languages at training centres strengthened for this purpose (1978-1985).

(b) Make available to Governments, on request, a consulting service on water management (1978-1985).

Recommendation 6

40. The degradation and destruction of dryland pastures is the most widespread form of desertification associated with animal-based livelihood systems, and has resulted in impoverishment and in physical and social hardship among many dryland pastoral communities. Regeneration of pastures and the establishment of systems of rangeland management to provide improved and sustained productivity are the main objectives of combative measures. Remoteness, scattered distribution and the traditional mobility of pastoral peoples have made it difficult to provide them with adequate health and social services. These and other related disadvantages must be remedied, with measures to assist sedentarization and resettlement where required.

It is recommended that measures be taken to ameliorate degraded conditions in dryland pastures, to introduce improved systems of rangeland and livestock management and to improve the lot of desert pastoral communities.

41. This recommendation calls for national action to:

(a) Improve degraded pastures through:

(i) surveys of the condition of the pastures and the extent and intensity of desertification;

29. Dryland farming populations in the developing world are growing at around three percent per year. Less in touch with modern medicine, nomadic pastoralists generally have higher death rates, with somewhat lower growth rates as a consequence. It would be unreasonable to expect either rate of growth to decline substantially in the immediate future - indeed, growth rates among pastoralists may well rise before declining. In this situation, a continued strong migration from the drylands to urban areas can be anticipated. Problems associated with migration and resettlement can thus be expected to persist.

30. National action is desirable to ease the transition of dryland migrants into urban areas. Many developing countries have already initiated programmes to this effect - to assure migrants of housing and other social amenities such as education and health services and to supply them with counselling on employment opportunities. Countries affected by such large-scale migratory movements can anticipate that programmes to ease the transition of migrants will be needed until at least the end of the century.

31. At the same time, national action would be desirable to reduce the selective out-migration of the most active age groups from rural areas. Improved land-use practices, as recommended elsewhere in this Plan of Action, will assist this task by enhancing the prosperity of the dryland economies. After determining the size and character of dryland out-migration, countries so affected may wish to consider additional measures to reduce excessive losses among those in the most vigorous age groups. Such measures could consist in supplying services to dryland peoples, including the development of alternative sources of income.

32. This recommendation also implies international action to make available to Governments, on request, an advisory service on problems related to migration from the drylands and the resettlement of migrants. The international community should also provide, on request, financial and technical support to programmes designed to ease the transition of dryland migrants into urban areas.

Recommendation 4

33. Areas vulnerable to desertification are often remote, far removed from centres of political power. Their populations are frequently dispersed and difficult to contact. This results in deficient health services, especially among nomads.

> It is recommended that programmes should be undertaken to provide dryland peoples with health care of a quality comparable to that provided to more accessible elements in the population, with particular emphasis on family health and family planning.

34. To implement this recommendation, national action should be considered to:

(a) Provide voluntary family health and family planning services to dryland peoples so that they can exercise the human right of parents to decide freely on the number and spacing of their children in conformance with the Teheran Declaration on Human Rights, and to

(ii) measures to aid regeneration, such as temporary protection from grazing, seeding or planting of desirable forage plants, and physical treatment to aid the re-establishment of plant cover in denuded areas;

(iii) water harvesting.

(b) Establish improved grazing strategies, through:

(i) assessing the productivity of pasture associations under a variety of conditions;

(ii) determining the impact of grazing on pasture associations and their requirements for regeneration under grazing;

(iii) devising methods of rotational and deferred grazing and planning drought reserves to maintain pasture condition under grazing.

(c) Establish improved range management, through:

(i) determining appropriate carrying capacities under a variety of conditions;

(ii) providing managed watering points to facilitate the recommended use of pastures;

(iii) establishing pilot or demonstration projects to demonstrate range management.

(d) Improve livestock management, through:

(i) the improvement of existing breeds and the introduction of new breeds and species;

(ii) the control of animal diseases and pests;

(iii) the development of improved methods of livestock management and their promulgation through extension services and demonstration projects.

(e) Reduce drought risks, through:

(i) the creation of drought forage stocks and drought grazing reserves;

(ii) the provision of means for removing stock from drought-affected areas;

(iii) local water harvesting or irrigation schemes for the production of forage;

(iv) integration with adjacent farming systems.

(f) Strengthen the economic basis of the pastoral industry by:

(i) establishing m. ' ' ' ' ng facilities and price stabilization schemes;

(ii) consideration of price controls to protect the livestock breeder in relation to other primary producers and the consumer.

(g) Protect the rights of pastoralists through planned land use supported by appropriate legislation, information and education.

(h) Promote the combination of controlled culling or ranching of wildlife with pastoralism.

(i) Promote alternative livelihood sources, such as craft industries and tourism.

(j) Provide health, welfare, and educational services compatible with dispersed and mobile populations, for example through the use of radio.

(k) Assist with resettlement or partial sedentarization.

(l) From the beginning, involve pastoralists in the planning and implementation of all measures that affect them.

42. This recommendation also implies international action to:

(a) Employ regional centres in the task of developing drought-resistant, high yield and nutritious forage plants and of organizing mechanisms for their widespread distribution. Such centres should also apply themselves to research and activities directed toward the improvement and adaptation of livestock (1978-85).

(b) Make available to Governments, on request, a consulting service for improving livestock and rangeland management (1978-85).

(c) Make available for country use methodologies for:

(i) the measurement of livestock carrying capacity of rangelands and improved pastures, taking into account seasonal variation and drought risk (1978-80);

(ii) determining the optimum size and composition of herds according to the measured carrying capacity of the land (1978-80);

(iii) planning and carrying out pasture rotation and deferred grazing (1978-80);

(iv) planning and carrying out the ecological and geographical stratification of livestock breeding, fattening and marketing (1978-80).

43. Areas of rain-fed farming in semi-arid and sub-humid lands have undergone extensive desertification through gullying and sheet erosion, the blowing away of soil, sand drift, and the growth of dunes. Degradation has followed extensive clearing, exposure and powdering of topsoil, and clean fallowing to store soil moisture. It is linked with the loss of soil fertility and the breakdown of soil structure after continuous cropping. A major factor in degradation has been the extension of farming into areas of high drought risk or on to marginal terrain, often under pressure of increased population. Some desertification has, however, resulted from the deterioration of structures for soil conservation due to labour shortages, for these are areas of strong out-migration to urban areas. In the tropics, degradation is associated with the shortening of cycles in farming and regrowth systems, again linked with population pressure.

44. The consequences have been lowered yields and loss of productive lands, with resulting economic, physical and social hardship, often associated with high rates of out-migration. Deterioration has adversely affected neighbouring animal-based livelihood systems. Combative measures for soil and water conservation must form part of comprehensive reclamation schemes, including for example the reforestation of watersheds. They may involve the removal of marginal lands from cultivation, the consolidation of holdings, and resettlement schemes linked to the provision of alternative forms of livelihood.

Recommendation 7

It is recommended that comprehensive plans for soil and water conservation be introduced to combat desertification in rainfed farming in drylands.

45. To implement this recommendation national action would be desirable to:

(a) Survey affected areas to determine land capability, degradation hazards and climatic risk, and put forward proposals for conservational land use.

(b) Assist the introduction of improved crop systems, including cover crops, rotational systems with legumes, and the use of organic and chemical fertilizers, to reduce exposure of soil and maintain fertility and soil structure.

(c) Assist with the reconstruction and introduction of works such as terracing for soil conservation and water management.

(d) Encourage the adoption of measures to counter erosion, such as strip cropping and shelter belts.

(e) Reclaim degraded lands, by such actions as stabilizing sand surfaces, levelling dunes and checking gully systems.

(f) Assist the afforestation of watersheds and the protection of upland pastures from excessive grazing or cutting for fuel.

(g) Encourage diversification in farming systems, with appropriate inclusion of livestock and tree planting.

(h) Introduce alternative livelihood possibilities, such as agricultural based industries and cash crops.

46. The recommendation implies regional action to develop, through regional institutions such as universities and their research establishments, improved agricultural techniques which resist desertification, drought-resistant and more productive crop varieties, and new cash crops.

47. Finally, this recommendation implies international action to:

(a) Develop and distribute to Governments, on request, information on training farmers in rainfed farming techniques, on strengthening extension services, and on farmer-training (1978-80).

(b) Develop and distribute to Governments, on request, a set of recommendations on: the use of improved fertilizers for dryland farming with special emphasis on organic manures and biological fertilizers that improve soil properties and the development of new plant varieties resistant to plant diseases and pests (1978-80).

Recommendation 8

48. Irrigated agriculture supports the closest settlement in arid lands, represents the most intensive form of primary land use, and is potentially highly productive. Nevertheless, many irrigation settlements are severely

affected by desertification. Waterlogging and secondary salinization or alkalinization of soils has caused a reduction in crop yields and abandonment of irrigable lands, and farm incomes in these areas have commonly become too low for an adequate livelihood. Irrigation is costly and requires skilled techniques if its benefits are to be realized; however, many irrigators are inexperienced and lack extension services or support through capital or marketing facilities. These conditions lead to a lack of incentive or opportunity for self-improvement. Many problems arise from the close settlement associated with irrigation schemes, such as disease, inadequate housing and community services, and lack of alternative employment for the families of irrigators.

It is recommended that measures be taken to combat desertification in irrigated lands by preventing waterlogging, salinization and alkalinization, by reclaiming deteriorated lands, by modifying irrigation and farming techniques to increase productivity, by developing new irrigation schemes where appropriate, and through improvement of the social and economic conditions of people dependent upon irrigation agriculture.

49. To implement this recommendation, national action is called for to:

(a) Improve water management through such measures as:

(i) reducing water losses during storage and distribution, through improved design, construction and maintenance of canals and ditches;

(ii) adequate watershed management to reduce silting and flood risks;

(iii) the determination of the water requirements of crops and the establishment of appropriate irrigation schedules;

(iv) advising farmers on the efficient application of water and associated tillage to retain soil moisture;

(v) the appropriate design of field and crop systems in schemes based on groundwater, in an effort to sustain water supplies.

(b) Improve drainage and salt-leaching through such measures as:

(i) investigating soil-water properties and the hydrogeology and salinity of groundwater before construction or reconstruction of irrigation schemes;

(ii) providing adequate drainage systems to maintain groundwater below the capillary zone;

(iii) providing adequate water for salt leaching;

(iv) undertaking the reclamation of salinized or alkalinized lands;

(v) establishing a network of stations to monitor groundwater ~~and salinity conditions;~~

(c) Improve farming systems through such measures as:

(i) soil surveys as a basis for devising appropriate crop systems in the light of available water;

(ii) establishing pilot or demonstration projects;

(iii) advising farmers on farming and irrigation techniques through extension services;

(iv) providing capital, and/or purchasing and marketing facilities, as through agricultural co-operatives;

(v) the encouragement of ancillary agricultural activities, such as rearing livestock or tree culture.

(d) Provide potable water supplies, sanitation and health services.

(e) Provide appropriate housing and settlements with community services.

50. This recommendation also implies international action to:

(a) Make available to Governments, on request, a consulting service for improved technology in irrigated agriculture. Elements of the United Nations now concerned with irrigation agriculture should be geared and co-ordinated to provide advice on the planning, design, and construction of irrigation systems, the reclamation of waterlogged, salinized and alkalinized lands, the investigation and monitoring of soil-salt-water relations, and the control of water-related diseases (1978-85).

(b) Make available to Governments, on request, advice on problems associated with social and economic conditions in irrigated areas (1978-85).

Recommendation 9

51. There is need to restore and maintain vegetation cover and to stabilize and protect soils in denuded areas, especially those affected by intense human impact, for example around settlements and near mining installations. This includes the requirements to stabilize moving sands and halt dune advance where land use, communications or settlements are threatened. Revegetation of desert uplands is necessary for soil and water conservation and flood control. On a larger scale, "green belts" to promote revegetation, soil conservation, planned land use and environmental protection are called for along desert margins and in other sensitive areas.

It is recommended that special measures for revegetation, soil conservation, and stabilization of moving sands be undertaken in areas of localized human impact, on watersheds, where resettlements, roads and farm lands are threatened, and along vulnerable desert margins.

52. To implement this recommendation national action is desirable to:

(a) Stabilize and revegetate lands degraded by mining, industry, tourism or other dryland activities, and prevent further degradation through:

(i) legislation requiring responsible organizations to undertake reclamation, and controlling further developments through requirements for environmental impact assessments and obligations to meet the cost of required environmental protection and of pollution control;

(ii) research into methods for stabilizing and revegetating degraded surfaces in desert areas, including soil treatments and the development of drought-resistant and salt-tolerant plants.

(b) Establish fenced reserves around settlements and along roads in other areas of intense human pressure, from which grazing, traffic and fuel-gathering are excluded.

(c) Control open spaces in settlements through revegetation or the provision of alternative stable pavements and the planting of shelter belts.

(d) Control traffic, particularly in and near settlements and at route intersections, through the surfacing and fencing of roads and by placing limitations on the use of cross-country vehicles.

(e) Revegetate watersheds for improvement of the hydrologic balance and soil conservation, as part of general programmes of catchment management.

(f) Check sand drift and arrest dune movement, with priority for areas where settlements, communications, farm lands, and important installations are threatened, through:

(i) surveying the extent of sand drift and dune advance, establishing the effective wind regime and sand sources;

(ii) checking sand drift by erecting fences, revegetating source areas and planting shelter belts;

(iii) stabilizing dune surfaces by the use of matting, mulches, or chemical or bitumenous coatings, vegetating dune surfaces, reshaping dunes and removing slip faces where necessary;

(iv) controlling land use in areas of stabilized dunes.

(g) Reduce the impact of the collection of plant material and manure for fuel, through:

(i) restrictions on fuel-gathering in sensitive areas;

(ii) establishing plantations for the controlled production of fire-wood;

(iii) making available alternative heating and cooking devices.

(h) Create "green belts" consisting of mosaics of revegetated areas and planted shelter belts in zones of conservation and controlled land use along desert margins and in areas of intense human pressure.

(i) Strengthen national forest, range management, and soil and water conservation services and other organizations involved in implementing these recommendations, including their advisory arms.

(j) Estr h or strengthen education, extension and publicity services; undertake programmes to create an informed and favourable public attitude towards reclamation and conservation in degraded areas; and, secure the co-operation and participation of communities in the proposed measures.

(k) Establish pilot or demonstration projects to test the feasibility of large-scale undertakings, train the required staff, and demonstrate the likely benefits to come from larger programmes.

53. This recommendation also implies regional action to implement measures suggested by the feasibility studies on transnational co-operatio for the establishment of "green belts" (1978-85).

54. Finally, this recommendation implies international action to:

(a) Establish or strengthen training centres for the specialists required for revegetation, afforestation, and sand stabilization (1978-85).

(b) Establish or strengthen revegetation centres for the production and distribution of plant material (1978-85).

(c) Make available to Governments, on request, a consulting service on dryland revegetation and afforestation (1978-85).

D. ALTERNATIVE ENERGY SOURCES

Recommendation 10

55. The use of alternative or unconventional energy sources in drylands, usually so favoured with sunlight and wind, should be vigorously investigated as a means of preserving organic materials, of reducing the tedious human labour so often involved with fuel collection, and of providing the peoples of the drylands with simple, inexpensive and convenient devices to serve their daily lives.

It is recommended that research be vigorously pursued on the use of alternative or unconventional energy sources in the drylands that will yield simple, inexpensive and useful devices to serve the needs of dryland peoples.

56. This recommendation implies national action to:

(a) Establish manufacturing facilities for the local production of whatever simple and efficient devices are produced by investigations into the use of alternative energy sources in the drylands.

(b) Establish distribution facilities to ensure that such devices reach the people who can use them, at a subsidized price when necessary. Distribution should be accompanied by instruction in the use of the devices which could be delivered by such agencies as extension services and fuel distributors.

57. This recommendation also implies international action to:

(a) Carry out research on the use of alternative energy sources, especially wind and solar energy, in the drylands. Such research should be keyed to the production of simple, inexpensive and efficient devices for the use of dryland peoples (1978-85).

(b) Carry out trials on the use of devices employing alternative energy sources and see that devices which prove efficient are brought to the attention of Governments, specially of those facing desertification problems (1978-85).

E. INSURANCE AGAINST THE RISK OF DROUGHT

Recommendation 11

58. As areas subject to desertification are at high risk of drought disaster due to natural climatic variations, the need for disaster relief and rehabilitation must be anticipated. If relief operations are carefully planned before the need arises, the operations will not only be more rapid and effective, but opportunities for social change created by disaster can be constructively used to promote programmes recommended in this Plan of Action. Explicit recognition of the risk of drought leads to insurance against the risk. Planning for disaster relief involves a set of financial and other measures to insure inhabitants of the areas at risk against loss of crops, livestock, means of livelihood, housing and food supply.

It is recommended to develop and adopt insurance schemes that provide facilities for coping with drought disaster and which promote the social and economic changes required to reduce long-term risks of desertification.

59. To implement this recommendation national action will be desirable to:

(a) Establish or reinforce, whichever is appropriate, crop and livestock insurance schemes.

(b) Create food, fodder, and fuel reserves against disaster.

(c) Plan in advance for disaster relief operations, bearing in mind the provisions of the present Plan of Action.

(d) Plan to take advantage of disaster to accelerate development programmes and to introduce changes.

60. The recommendation also implies international action to:

(a) Review the activities of disaster relief organizations with a view to their playing an enhanced role, taking into account the present Plan of Action (1978-80).

(b) Encourage and support climatological research that shows promise of making possible long-range weather prediction. Special emphasis should be placed on investigations that will make possible the long-range prediction of drought.

F. STRENGTHENING INDIGENOUS SCIENCE AND TECHNOLOGY

Recommendation 12

61. A lack of scientific and technological capability in many developing countries affected by desertification constitutes a serious obstacle to successful national campaigns against desertification. For this Plan of Action to be successful, indigenous scientific and technological capabilities must be strengthened, especially since the struggle against desertification is a long continuous process, and an essential aspect of national development. Although it is expected that detailed recommendation in this respect will be considered in 1979 by the United Nations Conference on Science and Technology, it is nevertheless appropriate to undertake certain essential measures within the framework of the present Plan of Action, which could serve as an input to this later conference.

It is recommended that appropriate action be taken to strengthen indigenous capabilities in science and technology for the purpose of combating desertification.

62. Although this recommendation concerns long-term action, the measures outlined should be initiated immediately if results are to be achieved within a reasonable time. The implementation of this recommendation calls for broad international support in the form of advice, technical and financial assistance, and training. This could be achieved through the mobilization of national and international resources, with the aid of agencies of the United Nations system and governmental and non-governmental organizations, including bilateral arrangements. National action would be desirable to:

(a) Designate or organize national centres for the transfer of technology and the dissemination of information on current progress in science and technology relating to desertification, and to provide advisory services on how to strengthen extension services that give instruction on the application of new technologies.

(b) Establish, co-ordinate or strengthen, whichever is appropriate, national institutions concerned with the problems of desertification.

(c) Provide existing scientific and technological centres with the equipment, material and funds necessary for their efficient operation; international or other agencies are invited and urged to aid established institutions which find it difficult to operate due to lack of resources.

(d) Establish or reinforce, whichever is appropriate, and with the help of international organizations, machinery for desertification monitoring (See Recommendation 1).

(e) Strengthen existing extension services for the promotion of improved land-use.

(f) Consider other recommendations of the present Plan of Action from the point of view of strengthening national capacities in science and technology, as this is an important factor in the implementation of most of the recommendations.

G. SUPPORTING MEASURES

63. Actions to be undertaken in information, education and training are ordinarily regarded as measures in support of the key activities proposed as recommendations in a plan of action, and are often listed separately. In the present Plan of Action to Combat Desertification, such supporting measures are not listed separately but are cited in the same section as the central action they serve to support.

64. Frequently, but not invariably, supporting measures will be regional or international action taken on request of a national Government to support that Government's goals and actions. As an example, consider Recommendation 9, paragraph 51, on revegetation, soil conservation and stabilization of moving sands. One proposed national action (52-j) to strengthen education, extension and publicity services can be regarded as a supporting measure. All suggested international action under this recommendation (52-a-b-c) can be regarded as supporting measures.

H. INSTITUTIONAL ARRANGEMENTS

Recommendation 13

65. Desertification is often a national problem, and accordingly a strong national machinery is necessary to combat it. In many countries, activities to combat desertification are scattered among various ministries and departments with no special arrangements to co-ordinate them. A variety of bodies with responsibility for the planning and development of arid and semi-arid zones often have powers that overlap. This constitutes an obstacle to technological progress and to the advance of measures for the recovery of desertification areas. In these circumstances it would be necessary to create national machinery for the elaboration and implementation of national programmes for combatting desertification.

It is recommended that where none exists national machinery to combat desertification be established.

66. To implement this recommendation it would be desirable to establish a national desertification commission or task force, consisting of high-ranking representatives of the appropriate ministries, agencies and institutes and community leaders and non-governmental organizations; or to assign the task of co-ordination to one of the existing national authorities (ministry, department or board). The function of this national machinery would be to co-ordinate and consolidate activities related to desertification, rather than impose a new administrative structure on an already overburdened civil service. Even so, this body must be administratively and scientifically supported by a small technical staff. Many countries have secretaries or commissions for the human environment or planning commissions which could provide the necessary staff support. In countries

where the desertification problem is serious, past and current activities have already produced much data and information, these responsibilities may be vested in the Council of Ministers.

67. The responsibilities of such national bodies might include:

(a) The analysis and evaluation of existing information regarding the problems of desertification;

(b) The preparation of a national plan of action to combat desertification that would co-ordinate all national activities;

(c) Arranging for the implementation of a national plan of action through national institutions;

(d) Participation in international or regional programmes, and maintaining liaison with regional and international organizations on problems of desertification; and

(e) Reporting to the Government on plans, results, obstacles or other related questions involved in efforts to combat desertification.

Recommendation 14

68. A facility for the effective co-ordination of international activity to combat desertification is needed. Taking into consideration existing international institutions and their fields of activity and the undesirability of creating new international bodies:

> It is recommended that the Environment Co-ordination Board should be responsible for following up implementation of the Plan of Action to Combat Desertification, and that a Desertification Unit should be established within the United Nations Environment Programme to co-ordinate the implementation of the Plan.

69. To carry out this recommendation, the Environment Co-ordination Board should be requested to report to the General Assembly every two or three years through the Governing Council of the United Nations Environment Programme and the Economic and Social Council on the progress of implementing the Plan of Action to Combat Desertification. 1/

70. The Desertification Unit would serve as a co-ordinating office for national, regional and international activity to combat desertification. It would be responsible for:

1/ General Assembly resolution A/RES/2997(XXVII) of 19 January 1973, establishing the ECB "decides that, in order to provide for the most efficient co-ordination of the United Nations Environment Programme, an Environment Co-ordination Board, under the chairmanship of the Executive Director, shall be established under the auspices and within the framework of the Administrative Committee on Co-ordination; further decides that the Environment Co-ordination Board shall meet periodically for the purpose of ensuring co-operation and co-ordination among all bodies concerned in the implemention of environmental programmes ..."

(a) The effective co-ordination of international activity to combat desertification;

(b) The preparation of periodic reports on the state of desertification;

(c) The preparation of recommendations on problems of desertification; and

(d) Liaison among agencies and countries concerned.

71. A Working Group on Desertification should be established within the Environment Co-ordination Board that would:

(a) Assist the Desertification Unit in the follow-up and co-ordination of the implementation of the Plan of Action; and

(b) Help in the preparation of periodic reports to the Environment Co-ordination Board on the same subject.

Recommendation 15

72. In spite of the knowledge accumulated through past and current efforts to combat desertification, there remain gaps in our understanding of the processes and phenomena involved, and still larger gaps in our understanding of how to apply existing knowledge to particular ecological and socio-economic circumstances. There are many centres and institutes throughout the world, both national and international, that carry out research relating to desertification, but their programmes and methods may not always be co-ordinated, nor pertinent to the central problems.

73. Some of the gaps in knowledge will undoubtedly be filled in the course of applying present knowledge to the actions recommended for immediate implementation. But other gaps will require a long-term national and international research effort.

It is recommended that an International Desertification Research Council should be established to be serviced by the Desertification Unit, (see previous recommendation) to co-ordinate global, comprehensive research programmes, embracing existing national, regional and international research centres and institutes, for the rapid and economical acquisition and dissemination of new knowledge regarding the problems of desertification.

74. The International Desertification Research Council would include in its composition directors of institutes with research functions, and would co-ordinate the international research effort. The Council would be serviced by the Desertification Unit to be established in UNEP. The functions of the Council would include:

(a) Establishing research priorities and allocating projects, giving special emphasis to the need to strengthen indigenous science and technology. The Council would also review progress and advise on the further implementation of projects.

(b) Arranging exchange and advisory visits among research bodies. The Council would also establish a system for the prompt international exchange of information on research findings and innovative desert technologies.

(c) Advising on means of supporting selected research programmes, giving special emphasis to the research suggested in the Plan of Action to Combat Desertification, such as studies on:

(i) drought-resistant crops;

(ii) dryland livestock;

(iii) alternative energy sources, with special emphasis on solar energy and wind energy devices;

(iv) the optimization of water use;

(v) desalination techniques;

(vi) mechanisms for getting information and innovations into the field.

(d) Selecting in each ecological region, embracing several countries of a region or of a continent, one of the existing national or international desert research centres to be designated as a regional co-ordinating scientific agency, with functions as in (e) below, but on a regional scale. Where necessary such centres should be given technical and financial support.

(e) Designating one of the existing international desert or arid-lands research centres as the co-ordinating centre for the international campaign to combat desertification; this centre would ensure that the research programme carried out through other institutions is comprehensive and co-ordinated, and its functions would include those under (d) above, as well as:

(i) the co-ordination and planning of research work and the assignment of research priorities;

(ii) identifying the particular capabilities of the institutions involved and allocating projects of international importance among them;

(iii) the dissemination of scientific information and new research techniques to the institutions involved; and,

(iv) organizing co-operation among the institutions for specific research projects, special inter-institutional task forces, workshops and scientific seminars.

I. ROLE OF INTERNATIONAL ORGANIZATIONS

Recommendation 16

75. The implementation of the Plan of Action to Combat Desertification will require close co-ordination of national, regional and international programmes. The services of the agencies of the United Nations system should be available, and their participation in the implementation of the Plan of Action must be ensured. The agencies of the United Nations system, in their respective fields of activity and within the scope of the Plan of Action, should give advice to Governments, on request, and should elaborate methodologies, co-ordinate and support scientific and technological research, facilitate the exchange of information, and provide financial and technical support for the implementation of the recommendations outlined here.

> It is recommended that the General Assembly request the Secretary-General of the United Nations and the administrative heads of the United Nations Development Programme, the United Nations Environment Programme, the United Nations Industrial Development Organization and the United Nations Conference on Trade and Development, and invite the executive heads of the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization, the World Meteorological Organization, the World Health Organization and the International Bank for Reconstruction and Development to support in their respective fields of activity international action to combat desertification in the context of the Plan of Action and to make appropriate provisions and allocations in their programmes.

76. The implementation of this recommendation would require a set of actions by the agencies concerned, including:

(a) The revision of current activities related to the problems of arid zones, and to the problems of desertification in particular, with a view to adjusting and co-ordinating them to conform to the Plan of Action. The revision should be conducted in close co-operation with the United Nations body entrusted by the General Assembly, on the recommendation of the United Nations Conference on Desertification, with co-ordination and follow-up. Priority should be given to the application of existing knowledge rather than to research programmes.

(b) The planning of advisory, financial and technical support for the Plan of Action, including budgetary follow-up, in the following fields:

(i) the training of land-use planners, natural resource and social survey specialists and other specialists as required;

(ii) the financing and co-ordination of regional programmes for research in land-use planning and management and in the improvement of specific land uses in areas vulnerable to desertification;

(iii) the financing and co-ordination of regional survey and monitoring programmes;

(iv) the provision of financial aid to Governments, on request, which have formulated acceptable schemes for land-use management;

(v) support for disaster prevention and relief programmes.

Recommendation 17

77. The participation of international institutions outside the United Nations system, both intergovernmental and non-governmental, will be an important factor in the successful implementation of the Plan of Action.

It is recommended that the United Nations General Assembly should request the Secretary-General to invite governmental and non-governmental organizations concerned with desertification problems to participate in the implementation of the Plan of Action to Combat Desertification with a view to co-ordinating their activities with the worldwide programme.

78. To implement this recommendation such organizations may find it necessary to increase their efforts to raise the resources necessary for the financing of technical co-operation programmes and projects related to research and the development of strategies, plans and programmes, feasibility studies, and the strengthening of institutions engaged on combatting desertification.

CHAPTER IV. FINANCING THE PLAN

79. It is perhaps not now appropriate to consider the establishment of new funds for financing specific operations of the magnitude of a global programme to arrest and, where possible, reverse the processes of desertification. Nor would such proposals be necessary if existing development assistance funds have built into them the degree of flexibility required to respond to new and clearly demonstrated requirements. For the most part, what is required, as far as regional and international financing of the Plan is concerned, are shifts in emphases and in priorities as well as a regrouping of funding in some circumstances to respond to the needs of the Plan.

80. In addition to the constraints that naturally arise in a period of financial stringency, there is also the constraint of limited resources already committed nationally to activities that may be expected to show a higher rate of return. High returns cannot be readily demonstrated in a Plan designed to arrest the degeneration of fragile ecosystems. Nevertheless, longer term outlays to guarantee the regeneration of lost land and the avoidance of disaster may be justified when set against the loss of productive land and the burden of emergency and crash programmes to provide relief from drought and its ensuing social and economic dislocation. These are concerns shared by the international community.

81. It is with these considerations in mind that this Plan has been prepared. By the time the United Nations Conference on Desertification takes place it is anticipated that it will be possible to include in the Plan realistic and realizable orders of magnitude of the financing involved for regional and international activities for the seven years 1978-1984.

This seems to provide a reasonable span of time for immediate action, as well as to give an indication of external support required for action in the least developed countries where domestic revenues are not sufficient to finance the counterpart services and facilities needed, nor is there capacity to direct scarce skills to these new and demanding tasks.

82. At this stage, therefore, it would seem appropriate to place emphasis, not so much on the orders of magnitude involved, but, rather the groupings of sources of funding that from their experience, involvement or concern, may be expected to assist in launching or underpinning different components of the Plan. The international community, both within and outside the United Nations system, has ample precedents in this. Lessons learned have been applied for example to the onchocerciasis control scheme in the Volta River Basin area, in the financing of international research centres through the Consultative Group on Agricultural Research and, more recently, in the approach taken by the United Nations Sahelian Office and by Club des Amis du Sahel towards Sahelian recovery.

/It would seem that the regional preparatory meetings could consider how similar groupings could best be drawn together in selected implementation of the Plan and the arrangements under which these could best be made and maintained./

UNITED NATIONS CONFERENCE ON DESERTIFICATION

TRANSNATIONAL COOPERATION TO COMBAT DESERTIFICATION

FEASIBILITY STUDIES

A REPORT BY THE SECRETARIAT OF THE UNITED NATIONS CONFERENCE ON DESERTIFICATION

PREPARED ON THE OCCASION OF THE REGIONAL PREPARATORY MEETINGS FOR THE CONFERENCE

ITEM 5

OF

THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETINGS FOR

THE AMERICAS
Santiago, Chile 23 - 26 February 1977

AFRICA SOUTH OF THE SAHARA
Addis Ababa, Ethiopia 12 - 16 April 1977

THE MEDITERRANEAN AREA
Algarve, Portugal 28 March - 1 April 1977

ASIA AND THE PACIFIC
New Delhi, India 19 - 23 April 1977

Secretariat of the United Nations
Conference on Desertification,
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I. GENERAL

A. The role of feasibility studies in the preparations for the Conference

1. The main objective of the United Nations Conference on Desertification is to give impetus to international action to combat desertification. To this end, the Conference will provide the international community with a Plan of Action to Combat Desertification. The proposed plan will establish principles and objectives, recommendations for action, and proposals for strengthening indigenous capacity in science and technology.

2. One of the sources on which the Plan has drawn in formulating its recommendations is a collection of studies assessing the feasibility of certain transnational cooperative activities.

B. Selection of titles and scope of the Feasibility Studies

3. The concept of the Feasibility Studies is to work towards transnational (intergovernmental) agreements which can also serve as models for large-scale international cooperation to combat desertification. Senior consultants to the Conference Secretariat and the ad hoc interagency task force established to assist the Secretariat identified four areas for these studies. On further discussion, the proposals were developed into these six feasibility studies:

a. Management of livestock and rangelands in the Sudano-Sahelian regions (SOLAR).

b. Management of major regional aquifers in north east Africa and the Arabian Peninsula.

c. Establishment of a North Saharan Green Belt.

d. Establishment of a Sahel Green Belt.

e. Monitoring of desertification processes and related natural resources in South America.

f. Monitoring of desertification processes and related natural resources in southwest Asia.

4. It was agreed that a feasibility study should stop short of engineering drawings, detailed specifications and financial plans. These would be included in the pre-investment studies to follow later. Nevertheless, it should include estimates of the magnitude of the financing involved.

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C. Procedure for Developing Feasibility Studies

5. In each case, a preliminary paper on the scope and content of the study was prepared by the Conference Secretariat and sent to concerned Governments, United Nations offices and agencies, selected international and regional bodies and consultants and experts. A panel of government representatives and experts who received the preliminary document was convened to consider and guide the preparation of the study. Whenever possible, an institution from the region concerned was chosen to prepare the study which was then circulated to Governments, United Nations Bodies and international organizations for comments. Another draft of the document was circulated for discussion before a second meeting of the panels which served as the occasion on which the Governments concerned expressed their agreement in principle, and proposed, whenever possible, initial steps for implementation and recommendations bearing on the Plan of Action.

II. MANAGEMENT OF LIVESTOCK AND RANGELANDS IN THE SUDANO-SAHELIAN REGIONS (SOLAR)

6. Countries involved: Countries initially selected include Chad, Mali, Mauritania, Niger, Senegal, Sudan and Upper Volta.

7. The nature of the desertification problem in these countries

The main causes of desertification in this region are: overgrazing woodcutting, burning of vegetation and the cultivation of marginal lands. Some researchers estimate that about 650,000 km^2 of land suitable for some form of agriculture or intensive grazing have been forfeited to the Sahara over the past 50 years along its southern edge. The productivity of a huge sub-Saharan zone is suffering damage from overgrazing and overly intensive cropping of marginal areas. In the Sudan, desert creeps into steppe, steppe creeps into the neighbouring savanna which, in turn, creeps into the forest.

8. In Niger, widespread death of trees has occurred, particularly of shallow rooting species in drier settings, such as Acacia and Cammiphora In grazing lands there was decline in dry-matter production from about 2,000 tonnes to 360 tonnes per hectare. This was coupled with a relative decline in palatable species and an increase in ephemerals at the expense of perennials or longer-lived annuals. There was sealing of soils, particularly those of medium-texture through trampling by stock near watering points and in favoured wet season pastures. Mobilization of sand on crests of previously stable dunes took place. This picture of Niger is true for most areas in the Sahel.

9. National concern and efforts Countries in the Saharo-Sahelian and Sudano-Sahelian zones are those in which desertification has recently assumed the most dramatic form. The nature of the problems faced in these countries and the similarity of factors at play, have prompted many of them to plan and implement projects directed against overgrazing and overstocking. The 1967-72 drought in these regions influenced the attitudes of Governments towards development planning, and high priority was accorded to integrated agriculture (embracing animal husbandry, crop production, fishery and forests) and to the development of the traditional sector. Several national and regional projects are in operation and programmes are under consideration, some involving bilateral and international assistance, yet success has been limited.

10. Serious concern with problems of desertification and the intention to halt desertification processes has been expressed on many occasions by the Sahelian countries and particularly during the meetings of the panel of government representatives and experts convened for the purpose of this feasibility study.

11. Problems and gaps in knowledge The second meeting of the panel of Government representatives and experts identified several problems and gaps in knowledge which require the immediate attention of national Governments and the international community. Foremost among them are those of a sociological nature. In the regions of extensive grazing, traditional pastoralism seems the most suitable method of converting the rangeland vegetation into products usable by man. The main difficulty lies in the pastoralists themselves becoming reponsible for the protection of land resources. This will require the development of new patterns of land ownership and social organization, both preferably based on existing social structures. Problems related to limited

12. Gaps in knowledge are essentially those relating to integrated research and to the transfer of suitable modern technologies. Research programmes should concentrate on the development of rotation systems comprising appropriate crops, possibly including animal draught and peasant operated fattening programmes. Plans should integrate plant and animal production to ensure horizontal stratification of livestock production in the Sahelian zone. To make the wetter ecological zones complementary to the Sahel, research should be directed to develop fodder species adapted to an African region with 400 - 800 mm rainfall and to popularize simple agricultural techniques to guard against erosion and the use of runoff waters to improve the water balance in cultivated lands.

13. The transnational project The proposed transnational project has been formulated with due consideration for the major constraints of the vulnerable zones and with the specific aim of preserving potential natural resources and to combating desertification. It is based on the following:

a. Despite the danger of damage to the environment caused by overstocking, the exploitation of natural pastures by domestic and wild animals must be regarded as the best way of utilizing the arid rangelands of the Sudano-Sahel.

b. Emphasis must be placed on an integrated approach in formulating and executing development projects; the absence of such an approach in the past was one of the main causes of the deteriorating situation in the Sudano-Sahel.

c. Extensive or transhumant grazing seems the best system for dry rangelands. Settling stock-raisers on the land within clearly difined perimeters, or setting aside areas traditionally used for grazing to establish ranches or irrigated farms, will probably accelerate the degradation of the rangelands and the worsening of socio-economic conditions.

d. Measures for the conservation of land resources should not be confined to the prevention of overstocking in the Sahel. Gurrent agricultural methods and systems of settlement in the region are important factors in the degradation of its land. The introduction of rotation, including fodder crops, and the establishment of artificial pastures could provide a partial solution.

e. Assistance should be provided to the countries of the region in planning for the development of vast under-used areas which could in the future be opened up for major settlement.

f. Regional stratification programmes which would lead to an increase in the prices paid to producers for young animals or those raised on the range until maturity; for example, through growing-out ranches and programmes for peasant-operated fattening on small farms, could contribute significantly to solving the desertification problem. The Guinean region seems to offer the best possibilities for growing-out ranches, whereas peasant-operated fattening and animal draught programmes are equally appropriate to either the Sudan or the Guinean region.

14. The transnational project is composed of the following elements:

Project 1. A Sahelian pastoral unit in an exclusively cattle-raising population. This is an extensive grazing unit on rangeland receiving less than 400 mm annual rainfall.

Project 2. An annex to an irrigated region to compensate the traditional cattle raiser of that region for the damage incurred by the loss of dry-season grazing. In this unit, animal production (growing-out or fattening) would be developed as a complementary activity.

Project 3. An agro-pastoral unit combining crop and livestock production in the wet savanna. This unit is to be located in regions receiving between 400 and 800 mm annual rainfall.

Project 4. A growing-out and fattening unit for Sahelian animals in the wet savanna. In the stratification scheme for animal production, this unit combines the production of fodder in rotation with food and commercial crops with animal draught and peasant-operated fattening.

Project 5. To ensure coordination and complementarity between these basic projects which could be separated and isolated from each other as components of the transnational SOLAR project, a coordination unit is envisaged as a component of or associated with Comité Inter Etats pour la Lutte Contre la Sécheresse au Sahel (CILSS) as the host organization.

15. Views and recommendations of the panel of Government representatives and experts The second meeting of the panel was held in Ouagadougou at the cordial invitation of the Government of Upper Volta on 22-25 November 1976. The following are the main views and recommendations of the meeting:

a. The meeting expressed unanimous support to the strategy of stratification of cattle production both horizontally within the Sahel and vertically throughout ecoclimatic zones as this approach reflects the national development policies for animal production in all the countries concerned.

b. Unanimous support was given to transnational cooperative action in order to make possible the necessary cooperation between the states. Government representatives identified basic projects for implementation within their respective countries. In some cases priorities were allocated.

c. A project must be designed in cooperation with stock raisers so that it will be understood and accepted by them.

d. The meeting recommended that the basic projects must be carried out under national responsibility, but first an inventory of available manpower must be carried out.

e. It recommended that a coordination unit should:

i) assure the coordination of projects;

ii) ensure the training of technical personnel; and,

iii) act as an information centre, particularly in the gathering of data from the projects, and their storage and dissemination among the participating states.

16. Links with the Plan of Action to Combat Desertification The proposed transnational project has technical, economic and social implications affecting many aspects of life in the countries concerned. Its principles and objectives have been incorporated into the Plan of Action. The strategy of stratification and of transnational coordination in its implementation has been recommended for similar ecological situations.

17. Follow-up Action Participating countries and experts recommended that a small mission be sent to visit each of the countries in order to:

a. identify existing projects and programmes directly related to or designed to serve the same objectives as SOLAR;

b. assess country needs and endorse national priorities;

c. look into the availability of manpower required for implementation of SOLAR. This would assist in advance planning of the training component stressed during the discussions.

18. As a matter of urgency, the panel requested the Secretariat of the Conference and CILSS to initiate preliminary action to implement SOLAR. The panel also requested UNEP and the Conference Secretariat to contact donor agencies and countries to get the SOLAR project off the ground and help in its implementation until it achieves its objectives. Some donors who attended the meeting agreed to the objectives of the project and pledged their support.

III. MANAGEMENT OF THE MAJOR REGIONAL AQUIFERS IN NORTHEAST AFRICA AND THE ARABIAN PENINSULA

19. Countries involved This study involves 12 countries in two sub-regions: Northeast Africa includes Chad, Egypt, Libya and Sudan; the Arabian Peninsula includes Bahrain, Kuwait, Oman, the People's Democratic Republic of Yemen, Qatar, Saudi Arabia, the United Arab Emirates, and the Yemen Arab Republic. Duo to similarity in geological structure and the prevalence of essentially arid conditions in modern times, it appears justified to include both regions in one project.

20. The Nature of the Problem Northeast Africa and the Arabian Peninsula represent conspicuous cases of desertification. The area of the region is about $9\frac{1}{2}$ million km^2 supporting a population of more than 80 million. With the exception of two countries, Egypt and Sudan, the other ten covered by this study are almost entirely dependent on groundwater for their needs, whether domestic, agricultural or industrial. Away from the Nile Valley, the only source of water in Egypt and Sudan is also groundwater.

21. All the countries involved in the study lie essentially in an ecological zone ranging from extremely arid to arid, with some semi-arid patches. In the extreme southern parts of the Sudan and Chad the climate passes into tropical.

22. Desert encroachment has occurred in the Arabian Peninsula and northeast Africa for the last several thousand years and may have accelerated in recent times by the actions of man. Problems caused by nature or man include intrusion of saline sea water with detrimental effects on groundwater potential. The injection of sea or brackish water into oilfields has adverse effects on the fresh-water aquifers.

23. National concern and efforts Most countries involved in this study have had long concern with problems of desertification. Their extensive irrigation systems should be viewed as efforts to reclaim vast areas otherwise lost to desert. In recent years efforts have been mounted to attack the problem from several directions. These include improved management of groundwater resources proper range management and sand dune fixation.

24. Problems and gaps in knowledge The similarity of the geological and climatological conditions in northeast Africa and the Arabian Peninsula has led to the development of regional aquifers of comparable characteristics and with common problems. Substantial knowledge has already been acquired on the regional aquifers. Much remains to be done, however, to establish a sound data base for determining guidelines and action for aquifer management. Some vast areas lack data. In others, data already gathered have not been properly disseminated. How much yield can be extracted without endangering groundwater potential in quantity, quality, and availability needs to be determined. In addition, there is often lack of awareness of water problems by the water user.

25. Problems include the unreliability of some data on groundwater resources, the lack of standardization in data presentation and the unavailability of certain data considered confidential. There are also problems in aquifer management caused by natural conditions or by the impact of human communities on the exploitation of these aquifers; for example, the intrusion of saline water and the injection of sea or brackish water into oil fields.

26. The Transnational Project The study report concludes that there is no doubt that intercountry cooperation is necessary at the regional level for studying shared aquifers, for screening, processing, interpreting and integrating all data available and for defining management guidelines. It is also necessary to achieve cooperation at the inter-regional level for comparing experience, exchanging information on methods and technologies and for carrying out inter-regional surveys and combining consultant assignments to reduce costs. Such cooperation can best be established through the execution of a transnational project.

27. Due to the large area of the project and the complexity of its problems, provision is made for a one-year preparatory phase during which a programme of activities covering a four-year operational phase would be elaborated.

28. The Preparatory Phase The basic elements for a project covering the preparatory phase are these:

a. Objectives:

The long-term objective of the project is to arrive at a rational, economical and continuing exploitation of the major regional aquifers of northeast Africa and the Arabian Peninsula. This objective is to be reached through the concerted action of the countries involved.

Short-term objectives are:

i) To coordinate present or future operations for the exploration, assessment and development of groundwater resources in the aquifers, especially when such operations have transnational implications. This coordination will be achieved through the exchange of information on methods and technologies and the results of the operations.

ii) To start additional pilot studies of a transnational nature and to introduce appropriate methods and technologies in their support.

iii) To organize continuing transnational cooperation for the management of the aquifers based on proper institutional arrangements.

iv) To carry out an in-service training programme for national personnel.

v) To prepare documents, such as maps and reports, providing a basis and guidelines for the management of the aquifers.

b. Institutional arrangements would include:

i) A technical committee, organized at the country level for all operations related to the aquifers.

ii) A technical steering committee, organized at the regional level. It would include one representative from each country of the regions. The steering committee would designate a regional representative who would assist in coordinating regional activities.

iii) An interregional coordinating office for the management of the regional aquifers (ICOMRA) would be established as a project of the United Nations system. This office would be directed by an international expert (coordinator) assisted by two regional representatives, consultants, and any other required experts.

iv) The inter-regional coordination office would work in close cooperation with all institutions and projects dealing with the aquifers. The steering committees together with the coordinating office would meet periodically.

c. Work Programme The proposed pilot projects are:

i) The exploration and development of an untapped sandstone aquifer on the borders of Egypt, Chad, Libya and the Sudan. For this study the necessary coordination would be affected with the projects now operating in Kufra (Libya) and in the New Valley (Egypt).

ii) The exploration and development of an untapped sandstone aquifer on the borders of the People's Democratic Republic of Yemen, Saudi Arabia and the Yemen Arab Republic.

iii) The exploration and development of submarine springs in the Arab Gulf.

iv) The management of a limestone aquifer on the eastern border of the Arabian Peninsula threatened by seawater intrusion.

d. Project support

i) External contribution

The external contribution is exclusively for the organization and operation of ICOMRA. The costs for personnel and equipment run to US$190,000.

ii) Government contribution

One Government would put office space at the disposal of the project on a permanent basis. All Governments would put such facilities at the disposal of the project on a temporary basis.

29. The Operational Phase:

a. Objectives and institutional arrangements are the same as for the preparatory phase. It is expected that after one year national, regional and inter-regional arrangements will have been made.

b. The work programme would include five types of operations:

i i) coordination of national activities;

ii) execution of transnational pilot projects;

iii) institution building for regional and inter-regional activities;

iv) training; and,

v) preparation of comprehensive reports and maps.

30. The Views and Recommendations of the Panel of Government Representatives and Experts: The second meeting of this panel was held on 7-10 December 1976 at Doha, Qatar, at the cordial invitation of the Government of Qatar. The following are the main views and recommendations of the panel meeting:

a. The meeting expressed unanimous support for transnational cooperation for the management of regional aquifers and also for the proposed transnational project.

b. Individual Government representatives identified the pilot projects in which their respective countries wished to participate.

c. Government representatives gave statements on present projects which would be complementary to or form part of the transnational project. They also provided information and data requested for more accurate formulation of the project.

31. Links to the Plan of Action to Combat Desertification The panel meeting recommended for inclusion in the draft Plan of Action the following proposals. (They are not reflected in the second preliminary draft of the Plan of Action before the regional preparatory meetings as the draft Plan was completed before the following recommendation had been formulated).

a. Every facility and assistance should be extended to promote inter-regional cooperation on matters related to the processes of desertification and groundwater which transcend national boundaries.

b. The plan should include a recommendation on the management of major regional aquifers in arid regions with emphasis on areas where the environment is threatened, and especially wherever the supply of water is endangered in terms of quantity, quality and availability. Special attention should be given to groundwater bodies crossing an international boundary, for which transnational co-operation is essential.

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c. As this transnational project is a major venture in the field of technical co-operation between developing countries and, as such, contributes in a tangible manner to the build-up of an indigenous scientific and technological capacity in areas affected by desertification, the Plan of Action should bring such activities into sharp focus and recommend them for high priority in financing and implementation.

d. A recommendation on the establishment of a large-scale data bank, a water resources institute and a training institute for water specialists, as well as on the preparation of comprehensive plans for the development of water resources, was passed to the consideration of the Secretariat of the United Nations Water Conference for inclusion in their Plan of Action.

32. Follow-up To start implementation of the transnational project the delegations of countries in the Arabian Peninsula intend to recommend to the Conference of Ministers of Agriculture of the Arabian Peninsula to be held in February 1977 that a technical steering committee be formed as described above.

33. Governments in both subregions were urged to express officially their interest and willingness to participate in a letter addressed to the Executive Director of the United Nations Environment Programme. As soon as two or more countries from each region have expressed their interest, steps will be taken to organize ICOMRA.

34. As a positive step for immediate action, the Panel recommended that countries involved should give priority to data collection on all aspects of the aquifers.

IV. TRANSNATIONAL PROJECT ON MONITORING DESERTIFICATION PROCESSES AND RELATED NATURAL RESOURCES IN SOUTHWEST ASIA

35. Countries involved The study covers four countries: Afghanistan, India, Iran and Pakistan. What is learned with respect to desertification is one vulnerable part of the region should be readily related to an testable in other parts of the region.

36. The Nature of the desertification problem The deserts and their margins in the region suffers from extremes of temperature, aridity and wind. Desertification in the form of deterioration and decrease of vegetative cover coupled with soil deterioration is widespread in the arid and semi-arid lands in the region. This has been mainly caused by overgrazing, overexploitation of the ligneous vegetation for fuel and construction, and clearing marginal land for opportunistic dry farming. Smaller in extent, but nevertheless very important economically, is the problem of waterlogging, salinization and alkalinization due to poor irrigation practices.

37. The whole of Afghanistan, excepting only small areas in the east and northeast, is vulnerable to desertification. India is crossed by a zone of arid and semi-arid land. Natural resource surveys have shown that 4.35 percent of western Rajasthan has already been affected by desertification processes and that 76.15 percent (162,900 km^2) is vulnerable. In western Rajasthan the cropping area has increased but the net productivity of nearly all crops has decreased. It is estimated that a forage deficit of 50 percent in 1957 has increased to over 70 percent today. Of Iran's 164 million hectares, it is estimated that about 80 million are sparsely vegetated and vulnerable to desertification through excessive pressure by man. In Pakistan, desertification appears in waterlogging and salinization on the one hand, and the deterioration of rangelands on the other.

38. National concern and efforts The degree of concern with desertification problems and the efforts directed against them vary in the region. The Government of India established a Desert Afforestation and Soil Conservation Station at Jodhpur in 1952. In 1955, this station was upgraded as the Central Arid Zone Research Institute (CAZRI). Five other institutions in India are concerned with one or another aspect of desertification. Major efforts include the Rajasthan Canal started in the early sixties to provide irrigation water for 11 percent (2.7 million hectares) of the total desert area, a World-Bank-assisted programme known as "Drought Prone Area Programme", and the creation of the Desert Development Commission for Rajasthan.

39. In Iran, consciousness of desertification problems has grown steadily since the fifties. Public and Government awareness reached a peak in 1975, and a coordinated programme for the conservation and development of Iran's desert areas is now being formulated. A number of institutions are concerned with research and development in and around Iran's desert areas. Their activities include sand stabilization, watershed management and the improvement of rangelands and vegetation cover.

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40. In Pakistan, salinity and waterlogging are major problems in irrigated areas, wind and water erosion in rainfed areas. The Government's concern with desertification has been growing. As a result, several institutions and programmes have been set up, including the Drainage and Reclamation Institute of Pakistan and the Mona Reclamation Experimental Project.

41. Problems and gaps in knowledge The countries involved in this study are threatened with a similar range of desertification processes. The feasibility study report deals with these in some detail for each country. It goes on to state that the pressure of human use, which in most situations has been increasing over recent decades has lessened the productivity of ecosystems. As the ground loses its cover, micro-climates change and soils deteriorate and erode. These problems occur throughout most of the area covered in this study.

42. The ability to move investments and switch resources into drylands of low productivity is an important factor in the long term prospects for the human use of systems in and around deserts. The technological flexibility which characterizes most traditional land use patterns in these areas is being lost or reduced because of changes in the larger socio-economic system of which they form a part and is a major cause of increased pressure on resources leading to desertification.

43. Gaps in knowledge and training are essentially related to the efficient monitoring of desertification processes and related natural resources which is required for improved planning, management and development. To be effective, monitoring requires a fairly complete survey of natural resources. At present there are gaps in the natural resource data base which cannot be filled by conventional means except at high cost. For this reason the programmes could be immensely assisted by the use of satellite imagery. Another gap relates to classification of areas as to their potential.

44. The proposed transnational project was revised and adopted by the panel in accordance with the following objectives:

45. The long-term objective of the project is to enhance the capabilities of the individual countries of the region to combat desertification and promote regional self-sufficiency. This objective would be pursued primarily by means of a co-operative monitoring programme, initially focused on pilot areas, in which satellite imagery would be processed and interpreted at a regional centre and the results reported to national committees for action. The regional centre would also carry out other functions that would allow the four countries to make the best use of the total facilities and expertise available and maintain a working relationship with remote sensing and desert research agencies in other parts of the world.

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46. The Institutional Framework Each country would set up a national committee on desertification and appoint a representative to a regional committee on desertification. The Regional Committee would function as the Governing Council of the Regional Centre, which would be the physical focus of the project, and would appoint its director.

47. Budget The cost of setting up the project is estimated roughly at US$85,000 for the first year and US$4 million from the second to the fifth years. The budget for the second five years will be estimated on the basis of a budgetary review at the end of the first two years.

48. Work Programme The Regional Committee would begin work as soon as possible on the following tasks:

a. Investigate possibilities for the establishment of the Regional Centre.

b. Draw up a list of training institutions in the region, select suitable institutions for regional training responsibilities, and make recommendations to the appropriate Governments.

c. Investigate and identify sources of financing.

49. The Regional Centre, as soon as established, should begin work on the following:

i) a documentation centre;

ii) the processing of satellite imagery for reports to National Committees;

iii) liaison with other international programmes and NASA;

iv) assisting Governments to increase public awareness of desertification problems throughout the region;

v) a detailed proposal for a regional training programme;

vi) remote sensing monitoring techniques; and,

vii) regional implementation of the Plan of Action voted on by the Desertification Conference.

50. Views and Recommendations of the Panel of Government Representatives and Experts The second meeting of this panel was held on 3-6 January 1977 at Jodhpur at the cordial invitation of the Government of India. The following are its main views and recommendations:

a. The meeting expressed unanimous support for transnational cooperative activity in monitoring desertification processes and related natural resources, approving the project as described in the previous section. It was considered important to start the project immediately in order to achieve some results before the Conference and not to lose the momentum already generated. The panel, therefore, recommended that the first and immediate step should be the establishment of a Regional Committee on Desertification.

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b. On the proposal included in the draft study to site the regional centre in Iran to facilitate close cooperation with the satellite receiving station there, the hope was expressed that Iran would consider this favourably.

c. To establish a strong base at the country level for effective work to combat desertification, the Panel recommended the immediate creation of National Committees on Desertification representing the various disciplines relevant to the problem.

d. In order to make the best use of existing facilities and to spread the activities of the project as widely as possible through the region, several training centres instead of one should be established.

51. Links to the Plan of Action to Combat Desertification The panel agreed to present the following recommendations for inclusion in the proposed Plan of Action to Combat Desertification:

a. It is recommended that regional centres be established for groups of countries that are particularly vulnerable to desertification and share ecological and cultural conditions to assist in the coordination of national programmes and organize maximum use of expertise available in the region.

b. It is recommended that specific international procedures be established for monitoring and assisting the progress of transnational and regional projects aimed at combating desertification.

c. Since attention to the human factor in desertification has, until recently, been generally neglected, it is recommended that special attention be given at the international level to harnessing expertise in the analysis and treatment of the humanfactor.

52. Follow-up As it was considered important to start the project immediately, each Government was urged to appoint its representative to the Regional Committee on Desertification. Governments were requested to convey their decision to the Secretary-General of the United Nations Conference on Desertification. Each of the four Governments was urged to establish its National Committee with inter-disciplinary composition. The National Committee should embark immediately on preparations related to the requirements of the transnational project, particularly in the selection of pilot areas, and in inventories of training centres.

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53. Considering the urgency of the desertification problem in Southwest Asia, the Panel requested the Secretary-General of the United Nations Conference on Desertification to arrange the first meeting of the Regional Committee as soon as countries have designated their representatives to that body. The meeting may be held in one of the countries involved and representatives of the United Nations family and other interested international organizations may be invited to attend.

V. FEASIBILITY STUDY OF A PROPOSED TRANSNATIONAL PROJECT ON MONITORING DESERTIFICATION PROCESSES AND RELATED NATURAL RESOURCES IN CRITICAL AREAS OF SOUTH AMERICA

54. The countries involved in this study are Argentina, Brazil, Chile and Peru. The study focuses on the dryland regions extending from the Peruvian coast to Patagonia. It also includes the semi-arid areas of northeast Brazil.

55. The Nature of the desertification problem in these countries The area identified in this study as vulnerable to desertification includes 2.5 million km^2. As in other parts of the world desertification results here from an interaction between land-use pressures, climate, geology, soils and natural vegetation. The most important processes appear as a decrease in rangeland productivity due to uncontrolled grazing, accelerated wind and water erosion and a loss of irrigated land due to salinization.

56 There has been a significant loss of agricultural productivity in this region over the last 50 years, but neither the extent of loss nor its present rate can be estimated accurately. However, some losses have been identified in certain countries. In Argentina, of an original 25 million hectares of hardwood forest, only 1½ million remain, and of 60 million hectares of all forest, 16 million remain. Fire is destroying vegetation in the central area of the country at a rate estimated at 100 km^2 annually. Inadequate control of grazing has caused a decline in herbaceous and shrub varieties and an increase in less desirable vegetation. About two million hectares of irrigated land have declined in productivity due to salinization and alkalinization, while erosion has caused extensive degradation and gullying.

57. As in Argentina, desertification processes in Chile have been the result of extensive cutting of forests for timber, overgrazing and inappropriate cultivation practices. Ecological deterioration has followed, as evidenced by:

a. the formation of sand dunes due to loss of stabilizing vegetation;

b. the formation of gravel and rock surfaces due to loss of soil;

c. the accumulation of salts and loss of productivity of irrigated agricultural land due to the use of saline water in poorly drained soils; and,

d. the loss of soil by water erosion on bare cultivated fields.

58. National concern and efforts All countries involved in this study have been concerned with dryland problems including the special problems of desertification. The reasons behind their concern include: the need to conserve natural resources threatened by irrational exploitation; the need to expand crop production because of population growth; and, the need to improve standards of living in arid and semi-arid areas.

59. In each of these countries, institutions and universities are involved in studies, experimentation and programmes relating to dryland problems in general and desertification in particular. Inventories of these institutions were presented to the first meeting of the panel of Government representatives and experts convened for this study in San Martin, Argentina, 26-29 April 1976.

60. Problems and Gaps in Knowledge The problem facing these countries is declining productivity and resultant economic losses. Related to this is the need to assign priorities to areas according to their classification as to high or low potential. This cannot be done without a complete survey of resources. Several gaps need to be bridged. Declining productivity and resource potential cannot be assessed without effective monitoring using satellite imagery combined with aerial photography and ground surveys.

61. The Transnational Project If the countries involved are to establish programmes to control desertification and to reclaim lost productivity, a better understanding of the extent and rate of desertification as well as the potential of natural resources must be developed. If such programmes are to be implemented, continuous monitoring will be required to evaluate the approach taken and to modify the programme when necessary. The proposed transnational project would be organized as follows:

62. While it is anticipated that measures to control and reverse desertification would be undertaken on a national basis, it is felt that regional cooperation would be valuable in order to share technical expertise, to develop standardized monitoring techniques and data bases, and to facilitate the transfer of successful measures for the control of desertification.

63. The monitoring of soil and vegetation patterns over the large area of concern can be done by a multistage approach based on satellite imagery analyzed in conjunction with available aerial photography and ground-survey data. Where the interpretation of data is uncertain or where more detailed information is required, ground surveys or new aerial photography may be required.

64. The approach proposed in this study should first be tested in small pilot projects with test areas in each of the countries involved over a period of about five years. On the basis of these projects, the approach would be refined; estimates of the required financial, technical and organization resources would be made and a programme to monitor the larger area of concern would be drawn up.

65. The long-term objective of the project is to enhance the capabilities of the countries involved to combat desertification. The immediate objective is to assess the technical, organizational and political feasibility of transnational cooperation in monitoring desertification processes. Specifically, an assessment is required of:

a. the use of satellite data as a basis for a continuing programme of monitoring;

b. the value of a computerized resource inventory system for management and planning; and,

c. the advantage of sharing facilities, expertise and experience among the countries involved. The duration of the project is five years and its estimated cost for the whole period is US$ 1.8 million.

66. Institutional Framework and Implementation The implementation of the proposed project requires the following steps:

a. In order to continue the work which has been done with the least possible delay, the Governments should immediately designate a representative to a Regional Committee, and the Committee should meet to plan the transnational project in greater detail and investigate and identify sources of funding.

b. The Governments should establish National Committees on Desertification to coordinate national programmes with the transnational project, establish a national data base for monitoring desertification, and identify national institutions which can provide training in relevant disciplines.

c. As the national data bases are established, and as satellite and other data are collected and analyzed, the national committees and the regional committee should consider the need for facilities which could perform the following functions on a regional basis:

i) provide a reference system for remote sensing imagery, maps, literature and other useful documentation;

ii) process satellite imagery and provide other data processing services;

iii) establish efficient communication channels with NASA and other relevant organizations outside the region;

iv) assist Governments in increasing public awareness of the processes of desertification in the region; and,

v) develop training programmes to ensure that trained scientists and technicians in all relevant disciplines will be available to carry out an ongoing programme to combat desertification.

67. The second meeting of the panel is scheduled to be held 17 - 19 February in Lima, Peru.

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VI. TRANSNATIONAL NORTHERN SAHARA GREEN BELT

68. The study covers the five countries on the northern side of the Sahara, namely Algeria, Egypt, Libya, Morocco and Tunisia. In each of them, a programme or a project to fight desertification is being formulated or implemented. The great advantage in coordinating these national programmes and projects constitutes the basis for studying the feasibility of a transnational cooperative activity which links the countries' initiatives. A meeting of Ministers of the countries concerned is to be held on 5 February in Cairo.

VII. FEASIBILITY STUDY ON A TRANSNATIONAL SAHEL GREEN BELT

69. The proposed Green Belt extends from the Atlantic to the Red Sea. The countries concerned are: Chad, Mali, Mauritania, Niger, Senegal, Sudan and Upper Volta. Cape Verde and Gambia will also be considered in the study. These are the countries on the southern side of the Sahara and are most affected by desertification processes accentuated by the recent drought. A study of whether such measures can be introduced is being completed.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

TRANSNATIONAL COOPERATION TO COMBAT DESERTIFICATION

Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America: A Feasibility Study

An Abridgement

PREPARED ON THE OCCASION OF THE REGIONAL PREPARATORY MEETING FOR THE AMERICAS

ITEM 5

OF

THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETING FOR THE AMERICAS

Santiago, Chile 23 - 26 February 1977

Secretariat of the United Nations
Conference on Desertification

Lima

19 February 1977

FEASIBILITY STUDY ON MONITORING DESERTIFICATION PROCESSES AND RELATED NATURAL RESOURCES IN CRITICAL AREAS OF SOUTH AMERICA

I INTRODUCTION

This study concludes that remote sensing technology can be used for monitoring desertification processes in the arid and semi-arid regions of Argentina, Chile and Peru, and proposes a pilot project to adapt the technology to the needs of this region and evaluate the usefulness of monitoring as part of programmes to combat desertification. It should be recognized that the technology proposed here is not unique to the problems of South America, and if the proposed approach proves to be valuable, it could be readily applied to other parts of the world.

II NATURE AND EXTENT OF DESERTIFICATION

The area under consideration is the broad band of arid and semi-arid lands extending diagonally across the continent from the Peruvian coast, through northern Chile and western Argentina, to Patagonia. There are two factors which dominate the atmospheric circulation in this region and determine the precipitation patterns, the cold Humboldt current flowing northward along the Pacific coast, and the Andes mountain chain which serves as a barrier preventing humid air masses from crossing the continent. The total area in this region vulnerable to desertification is about 2,500,000 Km^2, covering 60% of Argentina and Chile and 25% of Perú, including the most highly populated regions.

It is widely agreed that there has been a significant loss of agricultural productivity in this region over the last 50 years, but neither the extent of loss nor the present rate of loss can be estimated accurately. As in other parts of the world, the desertification processes result from an interaction between the pressure of land use, the climatological characteristics of the region, the geology and soils of the region, and the natural vegetation.

ARGENTINA

In a large part of Argentina, the vegetation exists in a precarious balance. While in many regions this balance has been respected and preserved, in others there has been a progressive deterioration and ultimately abandonment of the land. The population of the drylands tends to be rather mobile, and this factor, combined with the division of the land into either very extensive or very small holdings, discourages the capital investment and the scientific management necessary to maintain and improve productivity.

Although it is impossible to make accurate estimates of the total economic loss due to desertification, some losses can be identified.

- Of 25 million hectares of hardwood forest, only 1 1/2 million remain. Cutting has continued since the 19th century in all of the warm semi-arid regions. Of 60 million hectares of all forest, 16 million remain.
- Fire is destroying vegetation in the central areas of the country at a rate estimated at 100 Km^2. annually.
- Inadequate control of grazing has caused the decline of the desirable herbaceous and shrub varieties and an increase in vegetation types that do not provide productive grazing.
- Some 2 million hectares of irrigated land have declined in productivity due to salinization, alkalinization, and contamination resulting from inappropriate irrigation systems and low quality water supplies.
- Erosion by wind, streamflow, and rainfall runoff has caused extensive soil degradation and gullying.

CHILE

In Chile as in Argentina, the important processes of desertification are uncontrolled cutting of forests for timber, overgrazing of natural pasture, and inappropriate cultivation systems. These processes are widespread throughout northern Chile particularly in the Norte Chico where the destruction of the natural vegetation has had the greatest impact.

There is no data available on the extent of economic losses caused by desertification in Chile, but a number of processes are evident:

- formation of sand dunes due to loss of stabilizing vegetation
- formation of gravel and rock surfaces due to loss of soil
- solidification of clay or bogs due to lack of organic matter and to alternating periods of drought and rainfall
- decreased retention of fresh water
- accumulation of salts and loss of productivity of irrigated agricultural land due to use of saline water in poorly drained soils
- loss of soil by water erosion on bare cultivated fields

PERU

In Perú the arid regions are of the greatest importance because of their contribution to the national economy, concentrating approximately 80% of its population and almost all the agricultural, industrial and mining activity of the country. This demographic pressure and the resulting economic and social disjustment have caused the misuse of the natural resources resulting in desertification. The overcutting of woods for various uses, the over-irrigation in the alluvial valleys, the over grazing, the over intensive utilization of the land under inappropriate conditions and with primitive methods and the deterioration of the environment by the solid, liquid and gaseous effluents from the mining activity is an example of this extensive process.

While it is impossible to estimate the economic losses caused by desertification in Perú, some indication can be given of the areas affected by the desertification processes.

- Of 800,000 Ha. of irrigated agricultural land in the coastal desert, approximately 300,000 Ha. have been affected by salinization and poor drainage in different degrees.
- The Northern Coast forests, covering approximately 1,000,000 Ha., suffering a dramatic yearly decrease through indiscriminate felling and over grazing. These woods now extend to the central and interior areas of the Lambayeque, Piura and Tumbes departments, whereas there are references indicating that they were previously very near to the sea and twice their present area.
- The "Coastal Lomas, covering an area of about 800,000 Ha., are decreasing in exten -

sion and quality of vegetation because of the man-made ecological changes and in the past exceeded 1,000,000 Ha.

- The intensive use of steep land on the Western Andean Slopes and the interandean valleys and the over grazing in the high Andean regions have affected the soil quality and resulted in a rapid decrease of the vegetative cover.
- The deterioration of the land and vegetation in the upper part of the river basins in the coastal region cause periodic landslides and lateral erosion in the irrigated alluvial valleys.
- The continuous eolic action is altering markedly the soil characteristics on the southern side of the irrigated coastal valleys as well as in the newly irrigated regions in the areas that join these valleys.

III THE ROLE OF MONITORING

This study does not deal with the question of whether desertification is caused by the climate or by man. Rather it assumes that the climate is variable, both in the short term and the long term, and that man's activities must be appropriate to the current climatic conditions if maximum productivity is to be attained. It is apparent from the preceding section that inappropriate patterns of land use exist in many areas in Argentina, Chile and Peru, and that, as a result, productivity has declined. To control and reverse this decline, national programmes are required to promote appropriate systems of land use. While it would be technically possible to be detailed periodic surveys of land use and land capability in the region, it would be a slow and expensive process and, since most of this land is inherently of low productivity, such an expense cannot be justified. The problem therefore is to develop a rapid and inexpensive system for identifying and studying those areas where substantial loss of productivity has occurred, is occurring, or is likely to occur in the near future.

The data that has been obtained by remote sensing satellites in the last few years provides a new and useful tool with which to tackle this problem. Since 1972 the U.S. LANDSAT satellites have been collecting data over the entire world, and the data have been distributed without restriction. For most areas data have been acquired several times in the last five years and in some areas are being collected many times a year.

While these satellites provide the best available data for large area surveys of ecological systems and ecological change, they cannot provide all the needed information. In areas where more detailed or quantitative data are required or where the interpretation of the satellite data is not clear, additional information must be obtained from other sources including high altitude aircraft, low altitude aircraft, and ground surveys. In general, more precise information is acquired on the ground or at low altitude but at higher cost. The design of a large areas survey, therefore must use various levels so as to acquire a maximum of useful information at minimum cost.

In general, the monitoring of vast areas of drylands that are generally of low economic productivity consists of the following steps:

1) determination of what information is required at what level of detail, and how recent;
2) evaluation of the existing satellite data, aerial photography, maps and ground survey data with respect to the required information;
3) extraction of as much information as possible from the satellite data;
4) acquisition of new aerial photography and ground survey data if necessary to complete the information required.

The management of large quantities of data from diverse sources can be handled efficiently and inexpensively by recently developed computer techniques for data storage and retrieval. Resource data can be taken from various sources, at various scales, and with various degrees of accuracy and placed on a reliable base map for easy reference and use. The geographical area is divided into elements of any convenient size on the basis of an appropriate coordinate system. The characteristics of each element, with respect to climate, geology, soils, etc., can then be classified from remote sensing imagery or other observations, and computer based maps of these factors can be generated. Given a model which relates potential for a particular land use to these features, the computer can then classify each element as more or less suitable for that use. As new data are added periodically, the old data are retained and maps of changes in land use patterns or soil and vegetation conditions can be generated. If satellite data are available frequently, the extent and nature of seasonal change can be mapped, and as new satellites with new sensors such as thermal sensors are launched over the next few years, new data can easily be added to the system.

To adapt the technology to the ecological conditions and technical resources of the project region and to determine the value of the monitoring programme under the prevail - ing economic and social conditions, a test project will prepare such an information system for pilot areas in each of the countries involved. From the results of such a test project, the proposed approach can be refined, the usefulness of such system can be evaluated and the costs of extending the system to cover the entire area can be accurately assessed.

IV THE TECHNOLOGY OF MONITORING

To demonstrate the concept of the computerized data base and information system, a data base was set up for an area of one LANDSAT image, 185 km. by 185 km.; centred around Mendoza, Argentina. This area was selected because considerable resource information was available and because the scope of this study did not permit field work or aerial photography. The proposed project includes extensive field work and mapping of areas where little information now exists.

The sample maps that were generated are the following:

Basic Data Maps

- Soils
- Vegetation
- Geology
- Salinity

Evaluation Map

- Pasture Potential

The advantages of such a computer based information system over conventional cartographic approaches are three: (1) the basic data are registered according to geographic coordinates in an easily accessible and easily updated form; (2) from the basic data, the system can generate maps of development potential at any scale, and the models which relate development potential to basic data can be easily changed; and (3) for inventory purposes, the system can automatically measure the area of any feature.

V ORGANIZATION OF THE PROJECT

A. Institutional Arrangements

The purpose of the pilot project is to assess organizational and political feasibility of transnational cooperation in monitoring the processes of desertification. Specifically, an assessment is required of (1) the use of satellite data as a basis for a continuing programme of monitoring ecological change; (2) the value of a computerized resource inventory system for management and planning and (3) the advantage of sharing facilities, expertise and experience between the countries involved.

The assessment of the technology requires a small scientific group with adequate technical and administrative support. All of the countries involved have competent scientists and institutions in the disciplines involved in ecological change, and appear to have computer facilities which could be programmed with the data base system. While information and expertise will be needed from a number of institutions in each country, it would seem appropriate that one scientific institution in each country, be given overall responsibility for the scientific aspects of the project.

Some training in specific techniques of remote sensing interpretation will be required, and it is proposed that technical people from each country receive practical training at appropriate training institutions. In addition, international experts should work in the countries involved to assist with technical implementation and to assist the trained local personnel in further training.

An objective of the programme should be to make the region self-reliant in the fight against desertification. Since this will require a large number of trained specialists, the project should include the identification of existing institutions in the region which can provide training relevant to desertification and which might serve as regional centres of expertise.

The assessment of the value of the proposed information system for management and planning purposes is complex and requires that the scientific team have close connections with and the full support of the planning agencies. It must be emphasized that the computerized data base is more a management facility than a scientific research facility, and its value can only be assessed by an agency with management and planning functions. Such

an agency should therefore be designated to work with the scientific institution to ensure that the information system is organized to serve national policy. To ensure that the activities of the various programmes and institutions concerned with desertification are coordinated with the project, National Committees on desertification should be established in each country. These Committees should include representatives of a range of disciplines including the social sciencies as well as the natural sciencies.

Since resource management is basically a national responsibility, each country should designate a scientific institution and a planning agency to manage and evaluate the project. The problems of desertification are common to all of the countries, and since there are similarities in the social and economic conditions of the countries, it would be wasteful for each country to carry out the proposed studies independently. The remote sensing and information system technology is common to all countries, and the experiences of each country in applying the information system to resource management will certainly be valuable to the other countries. The facilities for receiving and processing satellite data are very expensive and should serve the entire region of coverage if possible, and the training programme and the visit of expert consultants can be more efficiently organized on a regional basis. To carry out these general policies of regional cooperation, a Regional Committee on Desertification should be established consisting of representatives of the governments concerned. The Regional Committee should meet at least twice a year with appropriate consultants and representatives of international organizations. If necessary the Committee might establish a permanent secretariat or technical centre to provide continuous coordination and expert assistance to the national programmes.

If the project is to monitor ecological change, it should be continued for a minimum of five years since it will require several years to establish a solid data base and five to ten years to demonstrate significant changes in the ecology of the region. At the end of two or three years, however, it should be possible to evaluate the costs and the value of expanding the programme, and planning for the next phase could begin at that time. A preliminary evaluation of the project should therefore be prepared at the end of the second year and should make recommendations for the organization and funding of a permanent programme to combat desertification.

B. Financial Requirements

While it is not possible to establish the exact financial requirements of the proposed 5 year project, some estimates can be made of the initial expenditures and of the operational costs.

It is estimated that about $310,000 per country would be required as initial expenses for equipment, training and consultants, and about $140,000 per country per year would be required for operational expenses.

VI IMPLEMENTATION

The implementation of the proposed pilot project requires the following steps:

1. In order to continue the work which has been done with the least possible delay, the governments should immediately designate representatives to the Regional Committee, and the Committee should meet to plan the transnational project in greater detail and investigate and identify sources of funding.

2. The governments should establish National Committees on Desertification to coordinate national programmes with the transnational project, establish national data bases for monitoring desertification, and identify national institutions which can provide training in relevant disciplines.

3. As the national data bases are established, and as satellite data and other data are collected and analyzed, the National Committees and the Regional Committee should consider the existence of and need for facilities which could perform the following functions on a regional basis:

   a. provide a reference system for remote sensing imagery, maps, literature and other useful documentation;
   b. process satellite imagery and provide other data processing services;
   c. establish efficient communication channels with NASA and other relevant organizations outside the region;
   d. assist governments in increasing public awareness of the processes of desertification in the region;
   e. develop training programmes to ensure that trained scientists and technicians in all relevant disciplines will be available to carry out an ongoing programme to combat desertification

UNITED NATIONS CONFERENCE ON DESERTIFICATION

TRANSNATIONAL COOPERATION TO COMBAT DESERTIFICATION

FEASIBILITY STUDIES

A REPORT BY THE SECRETARIAT OF THE UNITED
NATIONS CONFERENCE ON DESERTIFICATION

PREPARED ON THE OCCASION OF THE
REGIONAL PREPARATORY MEETINGS
FOR THE CONFERENCE

Add.1

ITEM 5

OF

THE PROVISIONAL AGENDA FOR THE PREPARATORY MEETINGS FOR

THE AMERICAS
Santiago, Chile 23-26 February 1977

AFRICA SOUTH OF THE SAHARA
Addis Ababa, Ethiopia 12-16 April 1977

THE MEDITERRANEAN AREA
Algarve, Portugal 28 March-1 April 1977

ASIA AND THE PACIFIC
New Delhi, India 19-23 April 1977

Secretariat of the United Nations
Conference on Desertification
P.O. Box 30552
NAIROBI.

February 1977

77-2-0359-150

67. The views and recommendations of the Panel of Government Representatives and Experts. The second meeting of this Panel was held on 17-19 February 1977 at Lima, Peru, at the cordial invitation of the Peruvian Government. The following are the main views and recommendations of the Panel meeting:

(a) The meeting expressed unanimous support for transnational co-operative activity in monitoring desertification processes, approved the main elements of the transnational project and endorsed a minimum period of five years for the project.

(b) The Panel recognized that the proposed list of features to be monitored should not be regarded as definitive and will likely be modified as the project progresses. Erosion was recommended for inclusion in the list and the use of remote sensing for studying historical land use and settlement patterns was recommended for consideration.

(c) The budget and time periods proposed for experts and training in the draft feasibility study report were accepted as reasonable. However, it was recommended that a detailed proposal on equipment, training, staff, operational requirements and costs should be prepared by a study group established by the regional committee.

68. Links to the Plan of Action to Combat Desertification. The Panel recommended the following to be considered for inclusion in the proposed Plan of Action to Combat Desertification:

(a) Realizing the importance of surveys of natural resources and monitoring of desertification processes in vast areas under high or medium vulnerability maximum use should be made of the available advanced technology of remote sensing in combination with other techniques in obtaining results in the shortest possible time and at comparatively cheaper costs.

(b) Since monitoring can serve a useful purpose only if it forms part of a programme to combat desertification, and since, in many countries, there exist project proposals, study groups and

/committees related

committees related to desertification, it is essential that monitoring projects be integrated with existing national and international programmes and policies.

69. Follow-up. As it was considered important to start the project immediately the Panel recommended that:

(a) Each government concerned should be urged to appoint its representative to the regional co-ordinating committee and establish its national multidisciplinary co-ordinating committee.

(b) The designation of a country representative to the regional committee should be communicated to the Secretary General of the United Nations Conference on Desertification who has been requested by the Panel to arrange administratively and financially for convening the first meeting of the regional committee.

VI. TRANSNATIONAL NORTHERN SAHARA GREEN BELT

70. The study covers the five countries on the northern side of the Sahara, namely Algeria, Egypt, Libya, Morocco and Tunisia. In each of them, a programme or a project to fight desertification is being formulated or implemented. The great advantage in co-ordinating these national programmes and projects constitutes the basis for studying the feasibility of a transnational co-operative activity which links the countries' initiatives.

71. The Nature of the Desertification Problems in these countries

Desert occupies three quarters or more of the three big countries (Algeria, Egypt and Libya) in North Africa. Generally the greater part of North Africa is characterized by an arid climate which gives rise to a vast desert north of 16ºN. Rainfall over a large part of the area is less than 25 mm a year.

72. The climate of the North African arid zone could conveniently be divided into desert, sub-desert and Mediterranean. The threat of desertification is faced in the latter two areas. In the sub-desert, about 25 per cent of the area is covered with vegetation, although much vegetation has been degraded over the millenia.

/The forest

The forest has almost disappeared due to uncontrolled burning and overgrazing. Several thousand hectares of grazing steppe or agricultural land are being lost annually to the desert. Soil erosion has affected extensive areas of land in all five countries and marching sand dunes blown by wind have decreased the area of productive agricultural lands. They have also caused severe damage to villages and transportation routes.

73. National Concern and Efforts

National concern with problems of desertification dates back several decades in all countries of North Africa. In Morocco, efforts have mainly been directed towards prevention of soil erosion and deforestation. In Egypt and Libya, sand-dune fixation and land reclamation have been the principal goals.

The study cites several projects, which have been implemented, and the successes achieved and also records the amount of lands reclaimed. In Algeria, the most important measure undertaken to combat desertification is the planning and initiation of a Green Barrier across the country to protect an area of 3.5 million hectares. In Tunisia, nearly two-thirds of the land is threatened by desert encroachment. This serious situation has prompted the Government to formulate and initiate programmes of sand-dune fixation, development and management of natural range, afforestation and other projects designed to prevent soil erosion and ecosystem degradation.

74. Problems and Gaps in Knowledge

The deserts in the five countries comprise extensive bodies of sand dunes and sandy soils. Movement of sand by wind causes great damage when sand overwhelms villages, farms, roads and fertile soils which are under cultivation or used for grazing. Accordingly, it is essential that measures should be taken to prevent and stop sand-dune mobility to avoid endangering the present populations. The feasibility report describes the problems of soil degradation caused by various types of soil erosion and states that millions of hectares are vulnerable to desertification processes of one type or another in all five countries.

/75. Effective

75. Effective measures to combat desertification require a determination of the areas most vulnerable to the hazards of desertification. Detailed maps showing degree of vulnerability do not exist and this constitutes a gap which calls for immediate attention. Although a great deal of work has been done, there still appears to be a need for mapping of vegetation and its classification, and the determination of the carrying capacities of natural pastures. Certain methods used in sand-dune fixation in some countries need to be tested and adapted to conditions in the other countries in the region facing the same problems. The report also points out the need to expand studies related to the control of biotic and abiotic agents which endanger plant life.

76. The Transnational Project

The proposed transnational project is primarily directed towards co-ordination of national initiatives in the five countries and setting up the intergovernmental machinery required to pursue this co-ordination. The main features of the project are described in the following paragraphs.

77. The Green Belt, is an interconnected belt across these five countries at the fringes of the areas where rainfall ranges from 150 to 250 mm per year. The green belt should not be conceived as a wall of tress grown perpendicular to the wind direction in order to reduce its velocity. It is a zone comprising a variety of devices for the prevention of further degradation of the ecosystem and the creation of an improved habitat. Soil stabilization, moisture conservation, afforestation, range improvement, appropriate plant and animal husbandry and dryland farming are among these devices. These need to be integrated within the green belt.

The width of the green belt will depend upon local climatic and topographic conditions. It may vary between a few to tens of kilometers. The exact location in each country will be determined after further study. Existing and on-going national schemes will be taken into consideration.

/Within the

Within the proposed green belt there may exist farms, shelterbelts, woodlands, ranges and other forms of land use. Each type should be treated separately and there may be variations in structure and composition from one location to another.

78. Protocol on Co-operation between North African Countries in Combatting Desertification

It consists of a preamble which describes the dangers facing the countries concerned from desert creep, the need for international and transnational co-operation to put an effective barrier against desertification. In its operative sections the protocol establishes a permanent Joint Committee with specific objectives and terms of reference. It also states the procedure and practical steps including a proposal for finances required to put the committee into action.

79. The Permanent Joint Committee is a regional body to be created by the protocol after signature by the five governments. Each government is to be represented by one member on the committee. The broad terms of reference of this Committee are the planning of a "transnational Green Belt", its implementation, and the co-ordination of the existing national desertification projects. The Committee would have a technical and administrative secretariat. The Governments of the five countries would provide the funds necessary for the functioning of the Committee.

80. Views and Recommendations of the Panel of Government Representatives and Experts

The meeting of the panel was held on 3-5 February 1977 in the building of the Arab League in Cairo. The following are its main views and recommendations:

(a) The meeting expressed satisfaction with the draft feasibility study report, and support for co-operative activity between the five countries in North Africa.

(b) The panel endorsed the recommendations in the study report as guidelines for the work programme.

(c) The draft protocol was polished and recommended for signature by the ministers of agriculture in the five countries.

/81. Signature

81. Signature of the Protocol

The Protocol on the Co-operation between North African Countries in Combatting Desertification was signed by the Minister of Agriculture in Egypt and the delegates of Libya and Tunisia, both officially representing their respective ministers of agriculture. The protocol is being taken for the signature of the Ministers in Algeria and Morocco.

82. Follow-up

Realizing the urgency of the desertification problems in North Africa, the panel requested:

(a) The Secretariat of the Desertification Conference and the Arab League Educational, Cultural and Scientific Organization (ALECSO) to undertake the preliminary work of the technical secretariat of the Permanent Joint Committee until the latter has been formally established.

(b) Each of the five governments concerned to appoint its representative in the Committee and to communicate that to the Secretary General of the Desertification Conference.

(c) The Conference Secretariat and ALECSO to complete all preliminary steps including the first meeting of the Committee by the end of June 1977.

(d) The Secretary General of the Conference and ALECSO to assume administrative, technical and financial responsibility for convening the first meeting of the Committee.

VII. FEASIBILITY STUDY ON A TRANSNATIONAL SAHEL GREEN BELT

83. The proposed Green Belt extends from the Atlantic to the Red Sea. The countries concerned are: Chad, Mali, Mauritania, Niger, Senegal, Sudan and Upper Volta. Cape Verde and Gambia will also be considered in the study. These are the countries on the southern side of the Sahara and are most affected by desertification processes accentuated by the recent drought. A study of whether such measures can be introduced is being completed.

INTERNATIONAL CO-OPERATION TO COMBAT DESERTIFICATION
GENERAL ASSEMBLY RESOLUTION 3337 (XXIX)

Draft Report of the Second Meeting of the Panel on Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America

Lima, Peru
17-19 February 1977

Table of Contents

Secretariat of the United Nations
Conference on Desertification

Lima, Peru
19 February 1977

77-2-0372-80

I. INTRODUCTION

1. The second meeting of the panel of government representatives and experts on monitoring desertification processes and related natural resources in critical areas of South America was held at Lima, 17-19 February 1977 at the cordial invitation of the Peruvian Government. The meeting was held at the premises of the National Office for the Evaluation of Natural Resources (ONERN). Dr. José Lizarraga Reyes the Director General of ONERN opened the meeting extending a warm welcome to all participants and assured the panel of Peru's co-operation in such an important co-operative activity. The opening session was also addressed by Mr. J. Labbens, the UNDP Resident Representative and Mr. G. Karrar the Representative of the Conference Secretariat.

2. Mr. Carlos Zamora Jimeno, leader of the Peruvian delegation was elected Chairman. The business of the meeting was conducted in eight sessions according to the agenda which was adopted at the beginning of the meeting and appears as Annex I.

3. Three of four countries invited attended the meeting, namely, Brazil, Chile and Peru. The meeting was also attended by representatives of international and regional organizations as well as consultants. The list of participants appears as Annex II.

4. Documents before the meeting included the provisional agenda, the calendar of the meeting, a note by the Secretariat on the Conference preparations and the draft feasibility study report. The note on the Conference preparations was presented in the first session.

II. STATEMENTS BY PARTICIPANTS

5. The representative of Chile supplemented the information contained in the draft feasibility study report on Chile by giving more data on the conditions of arid zones in his country. He then expressed the interest of his country in the transnational project

/and their

and their agreement in principle to participate. He requested, however, the panel to consider preparing a final list of equipment and realistic costs of the project.

6. The Peruvian representative summarized the characteristics of the arid and semi-arid zones of his country, its economic importance and the urgent need of protecting the natural resources in critical areas where desertification processes dominate. At the same time, he submitted a document on Peru to be included in the Feasibility Study report. He added that Peru, in view of the importance of monitoring among the actions to combat the desertification as well as the use of the techniques of remote sensing, expresses its interest and agreement in principle to participate in the project.

7. The representative of Brazil gave a brief description of the arid and semi-arid zones in his country. He stated that the conditions in these zones were different from those prevailing in similar zones in the other countries. Although Brazil is interested in co-operating technically in realization of the aims of the project it does not wish to have its arid and semi-arid zones included in the project areas at the present time.

8. In the absence of an official delegate from Argentina, Mr. Virgilio Roig informed the panel that his country, through its specialized agencies has given its approval to support and participate in the project. He added that these agencies are willing to direct their efforts towards initiation of action as soon as possible. The texts of country statements appear in Annex III.

9. The representative of the IDB stated that one of the main factors in the desertification process is the human action characterized by the overuse of an extremely fragile matrix of natural resources. The purpose of monitoring is to facilitate the action of the Governments and the agencies and individuals that must take political and managerial decisions destined to stop or reverse the process. It is therefore necessary that a socio-economic analysis of the process is made at the time as the physical analysis. For this purpose the national committee concerned in the desertification should

/include economists

include economists and social scientists which can evaluate the social costs of the process of desertification and estimate the expected net benefits of the actions destined to combat the process. To ensure that the methodology to be used should be common to all the countries participating, the national activities should be co-ordinated by a regional committee. The financing of the socio-economic studies could be included in the project budget or in the budget of existing national or international programmes.

III. THE FEASIBILITY STUDY REPORT

10. The leader of the study group, Dr. Roig, presented the second draft of the feasibility study report. He gave a summary of the nature and extent of desertification in Argentina, Chile and Peru. This part also included information on climate and types of ecological zones in the countries involved. The presentation also included the features to be monitored and their significance. Finally the transnational character of the proposed project was emphasized and placed within the context of the general philosophy of the Desertification Conference.

11. In his presentation of the technology of monitoring Dr. Myers stated that the technology of monitoring is presently a reality and is available for implementing a desertification programme. The main problems of a technical nature that remain are concerned with transfer of the technology to South American countries and making plans for analysis of resources, preparing a data base, and placing the data in a resource information system. It is suggested that a type of training be pursued that will qualify a few individuals from the respective countries thoroughly enough to enable them to conduct training seminars for additional scientists who become involved in the desertification programme. This transfers responsibility to individuals in South America and may be the most successful means of training scientists in the remote sensing technology. Such a training programme can be supplemented by short courses conducted by the United Nations and other groups.

/Ultimately the

Ultimately the above procedures will contribute to a successful information retrieval and decision-making mechanism which will aid in solving the desertification problems.

12. The panel recognized that the list of features to be monitored should not be regarded as definitive and will likely be modified as the project progresses. In particular, the panel agreed that erosion should be included in the list of features, and consideration might be given to the use of remote sensing for studying historical land use and settlement patterns. Similarly the numbers and time periods specified for consultants and training, while providing useful guidelines, should be left open for more detailed consideration later.

13. During the discussion on the technology of monitoring it was pointed out that while for most areas satellite imagery exists for establishing the proposed data base for pilot areas in the three countries, an ongoing programme for monitoring desertification requires regular repetitive data which can best be provided by local or regional satellite data receiving stations. In 1973 Brazil established such a station with the capability of receiving data for most of Peru and the northern portions of Argentina and Chile. Recently Argentina and Chile have signed agreements with NASA for establishing receiving stations but no construction schedules have been established. The United States has committed itself to launching a third LANDSTAT satellite in late 1977 or early 1978 which will provide data through about 1980. Plans are well advanced in the United States for a new series of satellites with higher resolution, about 30 m., to be launched in the early 1980s, and other countries are considering plans for such satellites.

/IV. THE

IV. THE TRANSNATIONAL PROJECT

14. The proposed transnational project, contained in Chapter V of the draft feasibility report was presented by the leader of the study group. The first section covered the objectives and the institutional arrangements required, mainly the creation of a regional committee and national multidisciplinary committees. The other section covered the financial aspects. Chapter VI dealt with implementation steps and the need for one or more institutions to perform the following functions on a regional basis:

(a) provide a reference system for remote sensing imagery, maps literature and other useful documentation;

(b) process satellite imagery and provide other data processing services;

(c) establish efficient communication channels with NASA and other relevant organizations outside the region;

(d) assist governments in increasing public awareness of the processes of desertification in the region;

(e) develop training programmes to ensure that trained scientists and technicians in all relevant disciplines will be available to carry out an ongoing programme to combat desertification.

15. The panel approved the main elements of the transnational project. On the duration of the project the panel endorsed a minimum period of five years to be reviewed during the first years of implementation. The budget estimates proposed in the draft study were accepted as guidelines with the details to be worked out at a later date.

V. PROPOSALS ON IMPLEMENTATION

16. In view of the above presentations and discussions, the panel made the following recommendations:

/17. That

17. That the governments of the countries involved designate, as soon as possible, a representative to a regional co-ordinating committee to continue the planning and co-ordinate execution of the transnational aspects of the pilot project.

18. That the governments communicate the designated representative to the Secretary-General of the United Nations Conference on Desertification with a request to convene a meeting of the regional committee with representatives of appropriate international agencies.

19. That the governments establish national co-ordinating committees with representatives of the various agencies and disciplines concerned with desertification, including the social and economic disciplines. Consideration should be given to the designation of existing committees for this purpose where possible.

20. That the next step in the execution of the project should be the elaboration of a detailed proposal. While the budget and the time period proposed in the feasibility study report appear reasonable, further study on equipment, training, staff, operational requirements and costs is required. This further work should be carried out by a study group established by the regional committee.

VI. PROPOSALS FOR THE PLAN OF ACTION

21. The panel suggests the following recommendations for inclusion in the proposed plan of action to combat desertification.

22. Realizing the importance of surveys of natural resources and monitoring of desertification processes in vast areas under high or medium vulnerability maximum use should be made of the available advanced technology of remote sensing in combination with other techniques in obtaining results in the shortest possible time and at comparatively cheaper costs.

23. Since monitoring can serve a useful purpose only if it forms part of a programme to combat desertification, and since, in many countries, there exist project proposals, study groups and

/committees related

committees related to desertification, it is essential that monitoring projects be integrated with existing national and international programmes and policies.

VII. CLOSING SESSION

24. The representative of Brazil Mr. Pereira thanked the Government of Peru and ONERN for hosting this meeting and reiterated Brazil's willingness to co-operate in the project by providing satellite image data according to the needs of the project. He was followed by the representative of Chile Mr. del Pozo, who expressed gratitude for Peru's hospitality as well as satisfaction in seeing the meeting arrive at a clear conclusion on the objectives and means of implementation of the project. Dr. Roig then added his thanks to the Government of Peru for their hospitality and sincerely wished that that the plans formulated before and during the meeting will become a reality.

25. Mr. Ralph Townley, Director of the Secretariat of the Desertification Conference, expressed gratitude to the Government of Peru for hosting the meeting and to ONERN for offering their premises and facilities. He also congratulated the chairman for the able manner in which he conducted the meeting. In his address, he described desertification as a synthetic concept and also as a perceived problem seen from different angles by the various scientists. The wealth of knowledge on desertification, he added, accumulated so far by the secretariat of the Conference has been used to develop an overview and a plan of action, and what we have accomplished today contributes in establishing a strong corner of the plan of action. He concluded by emphasizing the need for follow-up action.

/26. In

26. In his closing address the Chairman Ing. C. Zamora expressed Peru's pleasure in hosting this meeting and offering the facilities of ONERN for the service of such an important transnational co-operative activity. He stressed the fact that environment and desertification processes do not recognize political boundaries. Ecological studies should therefore be performed on this full coverage and not restricted by frontiers. He added that remote sensing was a valuable technique in the service of such studies and its use in this project should contribute to the realization of the project aims.

Annex I

INTERNATIONAL COOPERATION TO COMBAT DESERTIFICATION

GENERAL ASSEMBLY RESOLUTION 3337 (XXIX)

Feasibility Study on Monitoring of Desertification Processes and related Natural Resources in Critical Areas of South America

Panel of Government Representatives and Experts

Second Meeting

Lima, Peru

17-19 February 1977

AGENDA

1. Opening of the meeting and election of chairman

2. Adoption of the Agenda

3. Report by the Secretariat on the Conference preparations

4. Presentation of the draft feasibility study report

5. Country statements on the feasibility study report

6. Statements by other participants (United Nations agencies, international organizations and consultans)

7. General discussion and comments on the proposed transnational project in the feasibility study report

Secretariat of the United Nations
Conference on Desertification
United Nations Environment Programme
P.O. Box 30552
Nairobi, Kenya

17 February 1977
77-2-0363

Annex II

INTERNATIONAL COOPERATION TO COMBAT DESERTIFICATION

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Feasibility Study on Monitoring of Desertification Processes and related Natural Resources in Critical Areas of South America

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Annex I

INTERNATIONAL COOPERATION TO COMBAT DESERTIFICATION

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Annex III

INTERNATIONAL CO-OPERATION TO COMBAT DESERTIFICATION
GENERAL ASSEMBLY RESOLUTION 3337 (XXIX)

Draft Report of the Second Meeting of the Panel on Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America

Lima, Peru

17-19 February 1977

Statements by participants

77-2-0456-50

Argentina

After the presentations submitted during the meeting of the panel of experts and representatives of the countries concerned in the project, and because of the absence of the official delegate of the Government of the Argentine Republic, Mr. Virgilio Roig announces that his country's specialized national agencies (Argentine Institute for Research in Arid Zones (IADIZA), National Commission for Spatial Research (CNIE), and the Planning Ministry) have agreed to support and participate in the project and are willing to do all they can to secure its crystallization and initiation as soon as possible.

For this purpose these agencies will take the official steps to allow final approval at the level of a political decision by the Argentine Government. Without prejudice to this, the agencies in question also expressed through Mr. Roig their agreement to the modifications made in the project at the Lima meeting.

Brazil

I wish to clarify the Brazilian position on the matter under study. Having in mind the consequences for many developing countries of the desertification processes that are taking place, the Brazilian Government has great interest in the preparations being made for the Nairobi Conference. For this reason it is attending this regional expert meeting, with the aim of giving all possible co-operation in the solution of problems that affect countries which are friends and neighbours.

Because of not having participated originally in the drafting of the document under consideration, which proposes a programme applicable to regions with critical processes of desertification in Argentine, Chilean and Peruvian territory, the Brazilian Government would like to join the development of studies on this matter without, for the moment, taking a position on the specific aspects of the project.

/This attitude

This attitude of the Brazilian Government derives mainly from the physical and socio-economical characteristics of the semi-arid zone of the Brazilian Northeast, which can not be related to the problems of the above critical areas.

Although in the regions under consideration there may exist different features due mainly to the differences in climatic conditions, soils and vegetation, the problems of the semi-arid Brazilian zones are not identical with the desert and semi-desert areas covered by this study.

Despite the different characteristics of its Northeast region, however, Brazil is ready to co-operate with its neighbours in the study of this problem. For this reason, it is ready to examine with great interest the possibility of technical co-operation in the provision of LANDSAT data useful to this project.

Chile

The Chilean representative to the Panel approve the contains of the second draft of the study of feasibility of monitoring processes of Desertification, and agree in participate in a Transnational Project to combat and monitoring processes of Desertification.

Peru

The Peruvian Government acknowledges the efforts being made at the level of the world community to fight against desertification and views with special interest its participation in the Feasibility Study on the Monitoring of Processes of Desertification and Related Natural Resources in Critical Areas of South America.

In this light, the Peruvian Delegation, having participated fully and jointly in the revision of the document so that it reflects the real problems concerning desertification, has also proposed a possible pilot area for study, subject to modification by the high-level decision makers.

In addition, the Peruvian Delegation undertakes to take all necessary steps at the level of its Government to bring about, through the established official channels, the acceptance of the Project.

ARRANGEMENTS FOR THE UNITED NATIONS CONFERENCE
ON DESERTIFICATION

Note by the Conference secretariat for
provisional agenda item 3

1. The purpose of this note is to place the individual documents before the regional preparatory meetings in the context of the diverse activities undertaken to prepare for the United Nations Conference on Desertification. The participants in the meetings are invited to discuss the results of this broad programme of preparations.

2. The United Nations General Assembly, in its resolution 3337 (XXIX) on international co-operation to combat desertification, called inter alia for the convening of a United Nations Conference on Desertification to be held from 29 August to 9 September 1977. This Conference is now seen as the principal mechanism for giving impetus to current international activities to combat desertification and for starting new activities which, together with current actions, will constitute a concerted international programme of action against desertification as part of the rational social and economic development of desertification-prone areas.

3. As the Secretary-General of the Conference is also the Executive Director of the United Nations Environment Programme (UNEP), the secretariat preparing the Conference is administratively attached to UNEP. An ad hoc inter-agency task force has met four times to review in detail the secretariat's work. In addition, the secretariat has met several times with senior scientific consultants from around the world to receive their advice on the substantive preparations.

4. The preparations involve three principal activities. The first is assessment of available information on the causes and cures of desertification. To do this the secretariat commissioned scientific reviews of four components of the problem: climate, ecological change, technology, and population and society. These component reviews have now been synthetized in an overview of desertification. In addition, UNESCO has prepared, with UNDP financing, case studies of desertification

/and efforts

and efforts to combat it. The case studies were carried out in dry areas with predominantly cool season rainfall (Chile and Tunisia), dry areas with predominantly warm season rainfall (Northwest India and Niger), and irrigated areas suffering from waterlogging and salinization (Iraq and Pakistan). Additional case studies have been contributed by the Governments of Australia, China, Iran, Israel, United States and USSR. A synthesis of the lessons learned from these case studies has been prepared. Several countries and the United Nations regional commissions have prepared papers on national or regional experience in the combating of desertification.

5. Assessment activities also included the preparation of maps showing the areas affected or likely to be affected by desertification. In co-operation with UNESCO and WMO, FAO has compiled and produced a desertification map of the world at a scale of 1:25 million. These organizations have also prepared a more detailed desertification map of Africa north of the Equator at a scale of 1:5 million. The secretariat has commissioned a similar map for South America, as well as three more world maps at 1:25 million, one showing the degree to which the arid regions of the world have suffered damage due to desertification, a second showing the distribution of aridity and drought probability, and a third, a climate aridity index map, is incorporated into the component review on climate and desertification.

6. The second principal activity in preparing for the Conference was the formulation of a Plan of Action to Combat Desertification which is a set of specific action recommendations to governments and regional and international organizations, based on the information contained in the component reviews, case studies, and maps. The Plan is also based on the six feasibility studies for regional co-operation in the halting and reversal of the desertification process. These proposed regional co-operative efforts are management of livestock and rangelands in the Sudano-Sahelian region, establishment of green belts of planted or naturally regenerated vegetation on the southern and northern margins of the Sahara, monitoring of desertification processes and survey of natural resources in South America and Southwest Asia, and management of the major regional aquifers in Northeast Africa and the Arabian Peninsula. Drafts of

/these feasibility

these feasibility studies have been prepared after discussions at meetings of government representatives, consultants, and secretariat staff. It is hoped that regional arrangements to pursue these proposals will be agreed by the governments involved before the Conference. A summary of the feasibility studies has been prepared by the secretariat.

7. A draft of the Plan of Action to Combat Desertification has been circulated by the secretariat to all States Members of the United Nations and the specialized agencies, to interested United Nations bodies and agencies, to other intergovernmental organizations, and to non-governmental scientific experts and organizations for comments and suggestions. Based on the response to this wide circulation, a revised preliminary draft has been prepared for the third principal activity, which consists of four regional preparatory meetings of government-designated experts. These meetings are meant to give government experts the opportunity to discuss the relevance of the Plan of Action to their countries, to identify regional priorities, and to consider the institutions, technologies, and programmes needed to implement the Plan. On the basis of these discussions and a subsequent expert consultation on modalities for financing, the Plan will be revised for presentation to the Conference.

8. The regional preparatory meetings are being held in co-operation with the regional commissions of the United Nations, for the Americas in Santiago, Chile, 23-26 February 1977; for the Mediterranean area, including the Arabian Peninsula, in the Algarve of Portugal, 28 March to 1 April 1977; for Africa South of the Sahara, in co-operation with the Organization of African Unity, in Addis Ababa, Ethiopia, 12-16 April 1977; and for Asia and the Pacific in New Delhi, India, 19-23 April 1977. The reports of these meetings, as well as the documents before these meetings will be submitted for discussion and review on 12-13 May 1977 to the Governing Council of UNEP, acting in its capacity as the intergovernmental preparatory body for the Conference.

/9. As

9. As approved by the General Assembly, invitation to participate in the Conference will be sent to all States. The following organizations will be invited to attend as observers: (a) representatives of organizations that have received a standing invitation from the General Assembly to participate in the session and the work of all international conferences convened under its auspices; (b) representatives of national liberation movements recognized by the Organization of African Unity; (c) the United Nations Council for Namibia; (d) the specialized agencies and the International Atomic Energy Agency, as well as interested organs of the United Nations; (e) interested intergovernmental organizations; (f) interested non-governmental organizations that might have a specific contribution to make to the work of the Conference. The General Assembly also approved the use of Arabic, Chinese, English, French, Russian and Spanish as languages of the Conference.

10. The Conference is scheduled to be held from 29 August to 9 September 1977. It will be preceded by two days of informal consultations with governments to review procedural matters relating to the timetable and organization of the work of the Conference. The draft provisional agenda, as approved by the General Assembly, calls for the opening of the Conference to be followed by the election of a President, the adoption of the rules of procedure and the agenda, the establishment of committees and other sessional bodies, the election of officers, and the appointment of a credentials committee. It is expected that the Conference will then wish to hold a general debate and discussion in Plenary. The Conference will consist of the Plenary and a Sessional Committee of the Whole. The report of the Conference will be forwarded through the Economic and Social Council to the General Assembly at its thirty-second session.

11. Immediately following the Conference the secretariat plans to organize a workshop on the implementation of the Plan of Action to Combat Desertification, principally for representatives of governments and those engaged in field operations concerned with problems of desertification. Journalists will also be invited to attend. A draft proposal for the workshop has been prepared by the secretariat.

/12. As

12. As the success of the Conference depends critically on the quality of its pre-session documentation, particularly the draft Plan of Action, the participants in the regional meetings can play a crucial role in the Conference preparations by ensuring that the documents are scientifically sound, practically oriented, and politically acceptable.

DESERTIFICATION

IN

THE UNITED STATES

Jack D. Johnson

Office of Arid Lands Studies

University of Arizona

for the

U.S. Department of State

February 1977

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INTRODUCTION

This paper is an attempt to indicate the extent of the desertification problem in the United States. It includes a historical review of the land-use problems in the arid and semi-arid regions of the United States, discusses some of the current problems and emphasizes the need for concerted and sensible land-use planning and management if the U.S. is to curb its degradation of the semiarid and arid western lands and avoid the creation of deserts in those areas where land is being misused. Desertification is not a problem for the developing countries to tackle alone. Indeed it is a problem which the world must confront. The United States shares this problem, can offer some solutions, and will definitely benefit in the exchange of ideas and methodologies which will be presented throughout and following the U.N. Conference on Desertification.

In addition to the text this paper contains three appendices. Appendix A is an annotated bibliography of reading material, most of which was used in the preparation of the text, although specific references and quotes are not included as a part of the text. Appendix B is a partial list of activities which the U.S. government is either conducting or funding. The list could have included many other activities which are funded or conducted by the Soil Conservation Service, Bureau of Indian Affairs, Department of Commerce, Agricultural Extension Service, state and local governments, universities or other public or private institutions conducting research. To be all inclusive would require more time than was available, but Appendix B is representative of U.S. activities and interest in desertification.

Appendix C is a summary of this paper in Spanish.

DESERTIFICATION IN THE UNITED STATES

By Jack Donald Johnson

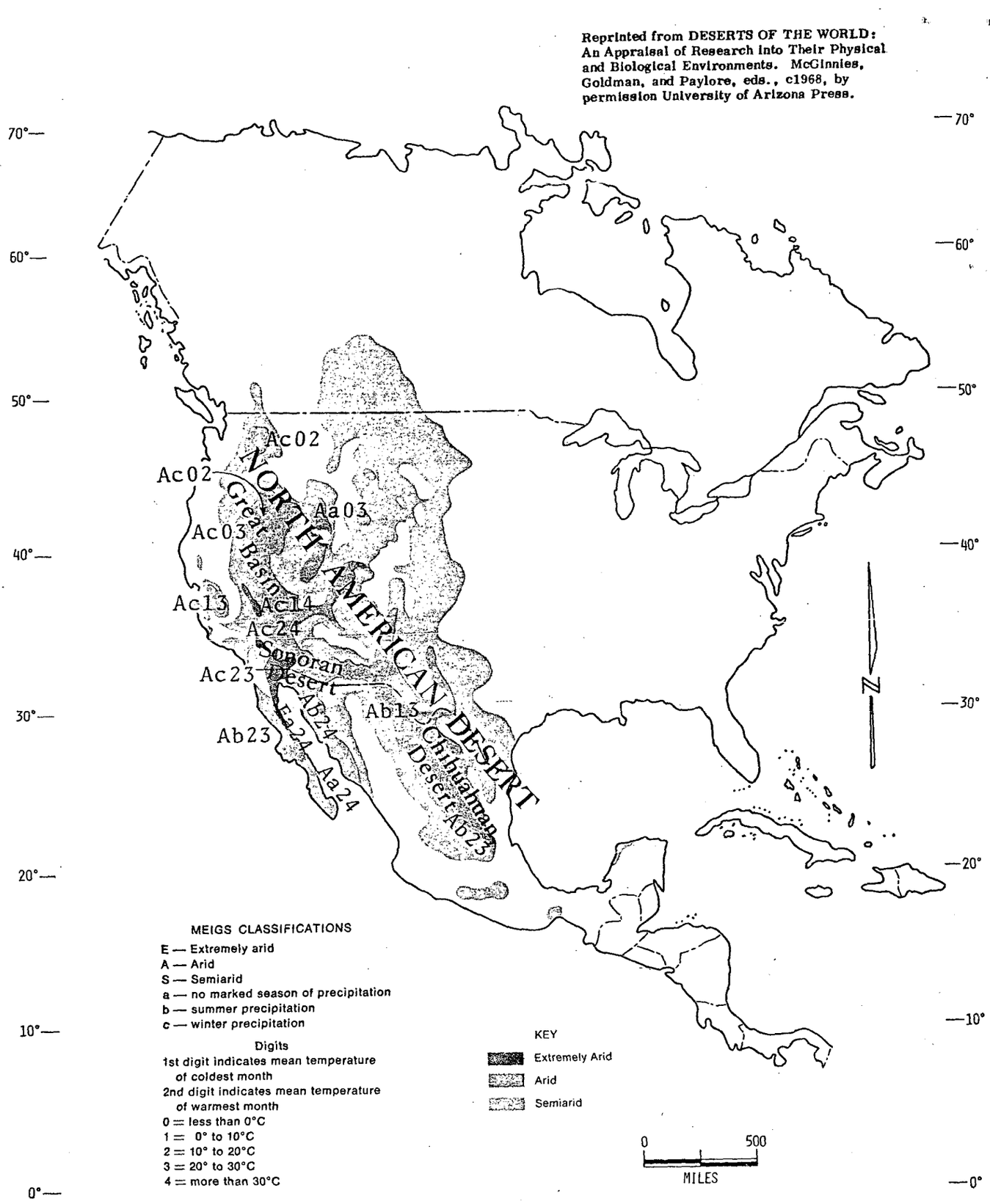
I. OVERVIEW

The total population (based on 1970 census) of the United States presently exceeds 203 million. The population of the 12 western states exceeds 45 million and is a little over 22 percent of the total population of the U. S. These same 12 states comprise about 40 percent of the total land area of the U.S. and almost all of the arid portions of the nation. (See map, page 2.) Approximately 23 million people reside in the arid regions of the U.S.

The 12 western states constitute a land area of about 1.4 million square miles. Seventy-two percent of this land, or in excess of one million square miles, is within the region currently or potentially subjected to desertification processes.

Population growth in the West during the last decade almost tripled that of the eastern states. The combination of 1) immigration, 2) migration from Mexico, north-central states and eastern states to the West, and 3) general population growth because of local birth rates is causing an alarming increase in the population of many of the western states. Land developers, chambers of commerce and individual businessmen expecting financial rewards are advertising and exploiting the arid regions.

In the populous eastern states the population density is high. In New Jersey, for example, there are over 953 people per square mile of land area, and in Washington, D.C. there are more than 12,400. In California, even with its large urban centers, the population density is only about 128, and within the other western arid states the population density is considerably less. For example, Arizona has about 16 and Wyoming about 3.4 people per square mile. This seems to indicate room for growth, but unfortunately growth from the large urban centers is rapidly expanding into the deserts and up into the mountains with little regard for the resources of arable land, water, vegetation and wildlife.



Arid Lands of North America (after Meigs)

Archaeological sites, ghost towns, abandoned ranches and empty farms that dot the arid West are dramatic examples of man's early failure to obtain a balance between his natural arid environment and his desire for expansion. When the earth was sparsely populated or uninhabited, land was abundant; man could abandon old environmental failures and move onto new lands. Today, the situation is much different; with expanding world population it is impossible to abandon or ignore the arid lands of any country.

Within the U.S. 60 to 70 percent of the arid lands are in federal or other public ownership. Some 130 million acres in arid lands states have been placed under multiple-use, sustained yield management within the national forests, which are administered by the U.S. Forest Service. Recent passage of the Federal Land Policy and Management Act has overcome some of the policy indeterminacy of the U.S. public lands, which are administered by the Bureau of Land Management. The new Act addresses the multiple-use and sustained yield management concept through an interdisciplinary land-use planning system.

One of the attributes of the rugged, arid western United States is that one can drive from the hot desert floor or large urban area into the dense mountain forests, often within a matter of minutes and never more than a few hours.

Irrigated agriculture is an important aspect of arid regions, and some irrigated portions of Arizona and California deserts comprise the most productive land in the U.S. It may not, however, be the most desirable or economically efficient use of water, and the expansion of irrigation farming farther into the desert requires a critical review. Much of the arid and semiarid areas is used as grazing land, and some of the arid regions are rich in mineral deposits, particularly in copper and coal. (Over 50 percent of U.S. copper is mined in Arizona.) Energy potential (solar, coal, uranium, oil and gas, and hydroelectric) is being exploited for use in large urban centers, particularly for Phoenix, Las Vegas and Los Angeles.

Recreation is rapidly becoming an important economic use of arid regions in the U.S. Surveys in desert recreational areas of Southern California during 1968 indicated that there were 570,000 people on one-day field trips; 1.1 million overnight trips; and about $30.9 million expended by these recreation users. Projections based on 1968 statistics of 4.9 million visitor days are that Southern California deserts will see 7.8 million visitor days in 1980 and 13.2 million by the year 2000.

One of the recreational uses which has recently received much publicity (mostly negative) is the use of motorcycles, "dune buggies" and four-wheel drive vehicles in remote desert areas. Because of the climatic and biotic conditions, physical scars on the landscape remain for centuries before nature can hide them. (For example, some of the tracks left by wagon trains crossing the arid regions of the western United States in the 1840s are visible today.) The lack of moisture slows natural decay processes and allows discarded waste products and containers to remain almost unaltered for long periods of time. (For example, a discarded paper tissue on the desert floor may remain as a visible symbol of human thoughtlessness for many years.) Pits from mining operations could possibly serve as recreational facilities or as sitss for other industrial development, but usually they simply stand as a reminder that man can dig a big deep hole in the ground.

Desertification, as a definitive process, has received only recent attention in the United States. But if we accept the concern regarding misuse of arid and semiarid lands, desertification concerns began sometime in the 1800s. In 1947 Dr. Walter P. Cottam authored a University of Utah Bulletin (Vol. 37 No. 11) entitled "Is Utah Sahara Bound?" Had he been able to predict today's use of the term "desertification," he might have used some other title such as "The Extent of Desertification in Utah." While economic data have not been researched for presentation herein, desertification does have serious economic impact. Arid land recreation and agricultural land are producers of a significant national income, and any reduction of that income through the desertification process has had and will have national consequences.

A recent disastrous drought of a few months' duration on the Papago Indian Reservation required emergency funds and services from several federal agencies and brought crippling losses of cattle and crops. The earlier experiences of the "dust bowl" in Oklahoma, the land reclamation programs, and the assistance to Indian reservations have totaled billions of dollars--and both the benefits of these expenditures and the burden of these costs are borne nationally. It should be emphasized that the U.S. experiences with desertification, reported herein, should be relevant to other arid and semiarid areas of the world, with the possible exception of some of the recreational uses.

II. HISTORY OF LAND USE IN ARID REGIONS OF THE UNITED STATES

There is evidence that man has lived in the arid and semi-arid regions of the U.S. for as long as 11,000 to 25,000 years, and ecological adaptations to the arid environments indicate a zone of extreme aridity in the Great Plains between about 5500 and 2000 B.C. Evidence from caves in west central New Mexico indicates that the period from perhaps 4000 B.C. to a few centuries before the beginning of the Christian era was a time of life based on cultivation. Established agriculture, however, did not replace the ancient food gathering practices until about 300 B.C. It was with the growth of cultivation and the improvement of agricultural techniques that the American Indian became capable of mastering many of the arid and semi-arid zones of the continent.

Until the middle of the 19th century the vast arid/semiarid region lying between the Rocky Mountains and the ranges bordering the Pacific Ocean was virtually unknown to the anglo. A century earlier Spanish missionaries had penetrated a small part of southern Arizona, introducting cattle to the scattering of Catholic missions they had founded there. They also made occasional trips across the intervening desert to the chain of similar missions along the California coast. These and other travelers, such as trappers and traders, did not write detailed descriptions of their travels; maps were not published prior to the 1840s.

The discovery of gold, which was in 1848 in California, brought tens of thousands of people across the desert region en route to the gold fields, but the arid area still lay virtually empty and unused until the latter part of the 1860s. From the early 1800s through the late 1860s grazing animals were brought into the Southwest by Spanish and Mexican missionaries and cattlemen. In the late 1860s there occurred an influx of settlers, chiefly comprised of cattlemen from the semiarid regions farther east. California presents some interesting statistics regarding sheep population which had increased to 1.9 million in 1860, 2.8 million in 1870 and 4.4 million by 1890. At that time, conditions in the arid West were far from stable and the nation was still recovering from the Civil War. Partially settled western territories were poorly administered, and the military and police forces were inadequate.

The following half century was the era of the open range. Herders laid claim to the widely separated watering places and thus held practical if not legal control over the vast waterless grazing lands. Land tenure was the major problem in the United States. The first attempt at control was the development of a General Land Office as an agency of the U.S. federal

government to administer and apportion public lands of the U.S. Under the Homestead Act of 1862 any citizen could attain title to 160 acres, but this Act was principally created for the purpose of developing the agricultural land of the East and the Midwest. One hundred sixty acres in the eastern and midwestern United States was adequate for maintenance of moderate to high standards of living, but land holdings of such small size were totally inadequate for enterprises in a semiarid or arid pastoral region. In most of the arid regions 160 acres would support no more than two head of cattle.

The Desert Land Act of 1877 provided that title might be obtained to a full section (640 acres), but that Act had only limited effect since it required that part of the land be irrigated. Most of the land in the arid West was not irrigable. In 1879 a federal commission headed by John Wesley Powell turned in its report on the governmental policies concerning the public lands of the arid West. The report stated that... "the Homestead and Preemption laws are not suited for securing settlement of more than an insignificant portion of the country."

Powell's report went on to suggest: 1) that land should be scientifically appraised and classified before settlement and that each category should be handled under laws specifically applicable to it; 2) that land must be disposed of in quantities sufficient to the establishment of working enterprises, and that the price of such a grant must be kept low...at least four square miles (2,560 acres) was proposed as a minimum; 3) that farm and ranch residences be grouped to permit a form of social life not possible on isolated ranchsteads; 4) that surveys should deviate from rectangular systems when necessary to divide irrigation waters properly; and 5) because of the great expense required to develop irrigation, irrigation schemes should be undertaken under the auspices of the federal government.

Unfortunately, no action was taken by the Congress of the United States on Powell's suggestions, which proved to be far ahead of their time.

During the 1890s and on into the early 1900s, particularly under the impetus provided by President Theodore Roosevelt, conservation measures were beginning to evolve. This was a rather stormy period in the grazing land areas where cattlemen fought farmers, sheepmen fought farmers, and cattlemen fought sheepmen. Pitched battles were waged over the right to build fences and section off land. In general the land was heavily overgrazed but the cattlemen were perceived as popular heroes with the "dirt farmer" and sheepmen getting the worst of most battles-- both physically and legally.

The Taylor Grazing Act of 1934 was the first major congressional action aimed specifically at the management of grazing lands of the arid and semiarid West. The Taylor Act was stimulated by the result of a 1932 survey indicating that rangeland productivity had declined by 50 percent and that grass removal had exposed 80 percent of the range to erosion. The Act established grazing districts and created the Grazing Service. Under federal control the number of animals was regulated to approximate a balance between range use and the forage-producing capacity of the land. It was fortunate that the Act was passed and implemented during the depth of the drought and the depression of the 1930s, for during that period the number of animals was already sharply reduced. The government therefore had to face principally the problem of preventing an increase in the animal population rather than having to bring about a drastic reduction. For administrative purposes a system of range inspection and evaluation was inaugurated to check on different stocking and management programs. Although relative stability has characterized the western desert ranges since the late 1930s, many areas are still poorly managed, and attempts at scientific grazing control are often frustrated by the complications of land tenure, multiple use of lands and the ease with which legal actions against agencies can be brought into the courts.

Many settlers migrating from the eastern United States brought their more humid region technology into the arid regions and attempted rain-fed farming. This usually accomplished nothing except to lay the land open to erosion by wind and rain, and in all cases failed to provide dependable crop production.

The development of irrigation in the arid portions dates back to the Hohokam and Pueblo Indians, but it was not until the 1840s that the anglos began irrigated agriculture. Among the first to establish successful irrigation farming were the Mormons in the Salt Lake City area. One of the reasons for their early success was the inseparability in the Mormon philosophy of church and state. Thus, it was relatively easy for them to establish a communal irrigation system and thereby allocate the land and water rights and obligations.

It was during the reclamation era of the 1930s and 1940s that the arid regions saw the harnessing of most of the major streams originating in the mountainous West. This resulted in multipurpose dams and the extension of irrigation to vast areas of the desert and semidesert.

Other land uses in the arid Southwest included Indian reservations, large urban centers, electrical energy production, mining and industrial development, and recreation.

III. RANGE RESOURCE UTILIZATION

As a result of the severe overgrazing which occurred during the late 1800s, the U.S. government has attempted to develop range control on its publicly owned land. Private, state-owned and Indian lands are not under federal grazing control, but through the Agricultural Extension Service associated with the Land Grant colleges and universities many improved range management techniques have been and are being adopted on non-federal lands.

Both the U.S. Bureau of Land Management and the U.S. Forest Service lands are grazed, in keeping with the multiple-use management concept. Multiple use may include recreation, timber production, mining, water resource development, transportation and power production. While multiple-use policy has its obvious advantages, it also leads to complications for the range manager. Range scientists are as yet unable to predict accurately the synergistic effects of multiple use on the carrying capacity of the land.

While severe overgrazing is generally prevented on most public lands, the result of multiple use is that the associated impact on range vegetation and soil requires continual assessment and re-evaluation of carrying capacity. Land tenure also complicates the problem in the U.S., as grazing may occur in a geographical area which involves land in which various parts are owned by the U.S. Forest Service, the U.S. Bureau of Land Management, Indian reservations, the states or private parties. The Indian reservations are generally severely overgrazed, and control of animal numbers is through tribal councils or cattlemen's associations. Indian cattlemen are reluctant to reduce herd size because to many the existence of a large herd is a source of savings, community power, influence and prestige.

Most range scientists agree that many of the public and private lands are being degraded, and that controls must be stepped up. There are many well-documented historical cases in which overgrazing caused the invasion of low woody plants of little nutritive value, the acceleration of erosion processes and depletion of groundwater.

Western cattle ranches today average over 20,000 acres with a carrying capacity of about one grazing cow per 100 acres. The economic stability brought to the desert ranch is largely a result of the transportation system, the development of water well drilling and pumping equipment, and the application of modern scientific methods in range management, breeding, feeding, veterinary medicine and marketing.

IV. IRRIGATED AGRICULTURE

Irrigation has literally transformed many parts of the deserts of the arid Southwest into agriculture production centers. Irrigation has, in the U.S., contributed to the desertification process via its consumptive use of scarce water supplies, salinization of soils, and, occasionally, the retirement of these agricultural lands to become barren wastelands.

The water problem is most critical in areas in which groundwater is being consumed faster than the rate of recharge to the groundwater system. Several streams and rivers that once were perennial are now ephemeral. This problem is particularly acute in those parts of the semiarid Southwest where groundwater is the only source of water. In the Santa Cruz Valley in southern Arizona, for example, water withdrawal for the urban center of Tucson, for irrigated agriculture and for mining copper is so far in excess of natural replenishment that the groundwater level has declined 200 feet or more in some areas.

One of the problems facing the irrigation farmer, who depends upon a declining groundwater supply, is that he must not only incur steadily increasing costs associated with the energy required to pump from ever-greater depths, but the rapidly increasing cost of energy itself. This places farmers in a position of exponentially rising costs and has caused many of them to abandon their lands. This abandonment of formerly productive agricultural lands leaves vulnerable top soil, which is often saline and does not naturally revegetate with low rainfall. As a result, the barren land serves primarily as a producer of windblown dust and sand. So severe is this problem that many motorists on the highway between Tucson and Phoenix have perished in auto accidents caused by blinding duststorms. This highway now has special sensor signs posted to warn travelers when duststorms are anticipated.

The salinization of soils is, of course, a well-known process associated with irrigation which may contribute to desertification. The general solution to the problem within the U.S. is simply to apply sufficient water to leach out the salts through a subsurface or well drainage system. While the solution clearly solves the problem locally, it results in other complications. It creates a downstream leachate that is higher in dissolved salts than the upstream waters, and, as our friends in Mexico are keenly aware, when the return flows are cycled through several uses, the end user receives water which may be too laden with salt to grow many crops. The Colorado River below Yuma, Arizona is just such an example, where the U.S. is now in the process of building a 100 million-gallon-a-day desalting plant.

Land abandoned because of salinity problems presents special difficulties in reclamation or revegetation with native plants. One of the greatest challenges of the future, one that numerous civilizations have failed to meet, is dealing with the effects of long-term arid lands irrigation.

V. MINING

While not particularly extensive in areal terms, mining can create a virtual desert locally. Mine reclamation is a field now receiving considerable attention. The effects of mining are different, depending upon the method and the ore body. This paper will discuss only two of the more obvious mining activities that have stimulated considerable public awareness.

Copper mining is extremely vital to the economy of Arizona, and it constitutues the major industry of the state. Most of the copper is mined in open pit operations that may be several square miles in top area and about 800 feet deep. There are several of these huge holes in the Arizona landscape, and the removed overburden plus evaporation ponds, holding processing wastes, create relatively large unproductive areas around the mine.

Architects have looked at the possibility of locating housing developments on the overburden, but for now they lie as unused waste, a tribute to man's ability to move a lot of dirt. This may be called desertification, but in general it is a local phenomenon and does not spread beyond the mine operation. Its visual impact is felt by residents or visitors for miles in all directions. The depletion of water resources required for milling may involve nearby or distant aquifers.

Coal mining in Arizona, Utah, Colorado, New Mexico, Montana and Wyoming has the potential to lay waste large areas. To date, strip-mining reclamation has had only sporadic success. The Four Corners area in New Mexico has such highly alkaline overburden that revegetation has failed, but in the Black Mesa area of Arizona and in parts of Montana and Wyoming strip-mine revegetation has been more successful. Huge deposits of coal and oil shale exist in the West, and exploitation seems inevitable. Many U.S. citizens, non-governmental agencies and governmental organizations are concerning themselves with the environmental impact of this exploitation, especially that which is related to the ~~coal~~ shale deposits that have both huge energy potential and huge land degradation potential. Recklessly approached, ~~coal~~ shale mining has the potential to desertify large expanses of land.

VI. URBANIZATION

Urban development may be one of the best uses of arid and semiarid lands, if proper planning and common sense accompany such use. While wasteful and improper water use in these cities may ultimately lead to ghost towns or concrete deserts, the most publicized problems are those caused by thoughtless land developers who carve up dry desert areas with roads in an attempt to sell these arid plots of waterless land to gullible easterners and midwesterners. A flight over New Mexico, Arizona and Nevada will reveal hundreds of these unpaved roads simply cross-hatching the land with no housing at all. On the ground one sees that many of the "streets" have become gullies which carry away the thin topsoils that typify the arid areas.

Another problem associated with urbanization is the demand for water and land. These demands often force agricultural lands to be retired, either to housing, as in the Los Angeles and Phoenix areas, or to simply unused lands so that the groundwater resource can be used by the city dwellers. Part of the once agriculturally rich Avra Valley in southern Arizona is in the process of becoming a wasteland and potential source of windblown sand and dust, because Tucson needs the groundwater resource for its increasing population. Population growth with the attendant demands for scarce resources is the basis for most arid lands problems.

Many of our western arid and semiarid areas were originally developed for irrigated agricultural usage. Recent population increases (largely attributable to the desirability of the climate for living), reductions in groundwater levels and quality, and increased costs of energy for high-technology agriculture that typifies these areas suggest that U.S. arid lands are on the threshold of a revolution in usage patterns.

VII. RECREATION

The plentiful sunshine of the arid regions, the general affluence of the average U.S. worker, plus more and more spare time have created an interesting and bothersome land degradation problem. As previously mentioned, motorcycles, "dune buggies," four-wheel drive off-road vehicles and campers have invaded the desert areas, and they leave their marks.

Although widespread, this problem is particularly acute in the Mojave and California deserts, on federal lands administered by the Bureau of Land Management. Eleven million Southern Californians view this unreserved public domain as "their own backyard." Use of the area by off-road vehicles was unregulated until 1972. During one 12-month period there were 151 organized competitive racing events for off-road vehicles involving more than 67,000 participants and 189,000 spectators.

The most extraordinary of the "scramble" races was run each Thanksgiving weekend over a 160-mile course between Barstow, California and Las Vegas, Nevada. Three thousand motorcyclists spread across the desert, traveling at breakneck speeds as they compact the soil, devastate vegetation, stir up clouds of dust and terrorize wildlife. The long-term results of such activities have been denudation of significant patches of the landscape. The Bureau of Land Management has subsequently canceled the races, but the damage remains.

VIII. PHREATOPHYTE AND OTHER VEGETATION CONTROLS

The demand for water resources in arid areas is always greater than the supply, causing agricultural, mining and municipal planners to be constantly devising new schemes for diverting larger portions of the limited water resources through the human portion of the desert ecosystem. Recently great concern has been expressed about phreatophytes. Rivers and washes, the arteries of our watersheds, are frequently bordered by stands of tall trees in significant riparian communities. Many of the trees are heavy water users, phreatophytes, and their elimination has been advocated in some areas. Phreatophyte control programs frequently include channeling water courses.

It has also been noted that vegetation could be stripped from several million acres of Arizona forest and desert (largely chaparral vegetation) to increase water runoff. Such schemes to remove large tracts of vegetation are possibly ill-advised because of the long-range degradation and desertification potential. In the short term, increasing water runoff through vegetation removal may mean less water infiltrating to groundwater, and sediment may accumulate more rapidly in water catchments and reservoirs.

IX. SUMMARY

While desertification is a relatively new term in the U.S. scientific vocabulary, land and resource misuse and degradation are not. Desertification is indeed a serious problem, with overgrazing, salinization of soils, depletion of water resources, land subsidence, population pressures, abandonment of lands, some mining operations, and destruction of vegetation or desert pavement through careless recreation, and other exploitations of the desert resources all contributing factors.

To ignore the impact of desertification on the U.S. is a mistake. While very high-level U.S. technology (and capital expenditures) has tremendous capacity to produce, it has equally tremendous capacity to destroy. If resource planners and managers, private investors and government regulatory agencies do not establish and maintain awareness and vigilance of land degradation in the Southwest, desertification could become a problem of increasing national impact. We have the technical knowledge to control and in some instances to reverse the land degradation, but as in many countries the pressures from a too rapidly increasing population coupled with the social problems of implementing known technology do not permit a careless optimism.

It is for these reasons that U.S. government agencies have undertaken a variety of activities aimed at control and possible reversal of arid lands degradation. For instance, in 1968 the Bureau of Land Management launched a California desert study. Its purpose was to inventory current and prospective land uses in the first step toward introduction of integrated management. The study focused public attention on management needs of the fragile arid lands environment creating a gradual increase in management awareness. As part of the Federal Land Policy and Management Act, the Bureau of Land Management has been directed to effect an interim management plan pending development of a comprehensive multiple-use, sustained yield plan for the Southern California desert conservation area. The interim plan will emphasize orderly public use and authorizes a patrol to ensure public safety and to enforce orderly use of the lands. The comprehensive plan will be developed through the Bureau of Land Management Land Use Planning System. A permanent federal appropriation of $40 million has been authorized to support the undertaking.

APPENDIX A

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The pre-Columbian Hohokam Indians occupied the major river drainages of central Arizona and have been the subject of much intense archaeological research. Evidence indicates that the Hohokam began using river water for crop irrigation about 300 B.C. and modified and improved their irrigation systems over time until the maximum extent of these systems was achieved about 900 A.D. Two types of water control seem to have been utilized: 1) the direct exploitation of rivers through the use of irrigation canals, and 2) indirect use through controlled runoff within micro-drainages at higher elevations before it reached the rivers. At first, probably only those parcels of land with optimal soils and drainage were used, but apparently population increases fostered by agriculture itself, combined with increasing social and political complexity, necessitated more and more exploitation of marginal lands. Eventually, soil problems increased, imposing severe limitations on agriculture. These involved salt and alkali accumulation due to inadequate drainage, soil density and waterlogging. Additionally, the extension of cropping required the clearing of natural vegetation, which resulted in increased erosion and decreased available native food resources for periods when crops failed. The culture vanished completely about 1450 A.D., probably mainly because of their manner of river exploitation for irrigation. More recent archaeological studies are concentrating not only on river use but also on river abuse.

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The dust bowl in the 1970s. Association of American Geographers, annals 61 (1): 1-22. GA 72C-0326.

Major droughts in the grassland region of the central U.S. have occurred rhythmically during the period of instrumental record. The time for the next one may be near. Early droughts disastrously reduced farm income through loss of crops and livestock. Since the 1930s they have accelerated contemporary basic changes in Americans within this region: fewer, bigger and more fragmented farms; public controls and subsidies; consolidation of urban business and services; and greater management. The next major drought will again accelerate long-term agricultural trends, but a sharp increase in urban federal assistance is likely, and revolutionary changes in settlement could be initiated.

Brown, G. W., Jr., ed. 1968-1974
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The first volume deals with the biological aspects of the world's deserts. It focuses on the forces causing desert and arid regions, the evolution of desert plants, water economy, desert ecology and limnology, poisons, desert animals, and the adaptation and behavior of plants, reptiles, amphibia, birds, fish and mammals (including man). The second volume discusses hydrogeology of arid regions, desert soils, physical and vegetational aspects of the Sahara Desert, desert algae, lichens and fungi. A new approach to water relations of desert plants, desert anthropods and fishes, and man in arid lands (particularly the Pima Indians of the Sonoran Desert and the Mada in Salih Valley in the northwestern corner of Saudi Arabia).

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Irrigation has modified the environment of the central valley of Arizona for past 2500 years, beginning with the irrigation systems of the Hohokam Indians. Modification of the physical environment has included changes in climate, groundwater, surface water and vegetation. The social environment has been changed from a rural economy to an urban industrial economic system. Present and future problems related to irrigation in the area are discussed. Some of the problems are water demand, land subsidence, salinity, groundwater management and allocation of Colorado River water. Solutions to some of these problems are suggested.

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Two canyons in the Wasatch Mountains near Salt Lake City were compared: Red Butte Canyon had been protected from grazing for 40 years, while Emigration Canyon had been grazed heavily since settlement in 1847. Evidence points to the complete substitution of the original grass type in Emigration Canyon to one with unpalatable shrubs and Bromus tectorum, while Red Butte Canyon has maintained a rich plant cover including ten native grasses not found in Emigration Canyon. Sheet and gully erosion are prominent in Emigration Canyon.

Denevan, W.M. 1967
Livestock numbers in 19th century New Mexico and problems of gullying in the Southwest. Association of American Geographers, annals 57(4): 691-703. GA 69A-990.

In the 1880s intensive accelerated erosion began producing large gullies throughout the southwestern U.S. This modern arroyo cutting was originally attributed to deterioration of the protective vegetation cover because of below-normal rainfall and overgrazing by excessive numbers of livestock (4 million sheep in New Mexico in 1880). However, recent studies have stressed the greater importance of increased high intensity rainfall. Additional perspective is provided by an examination of livestock numbers in the upper Rio Grande region of New Mexico during the 19th century, particularly during the Mexican period when the ranges were heavily stocked with sheep (possibly 3 million head in the 1820s), but with little or no gullying. The incomplete record of livestock numbers in relation to climate and gullying backs up the climatic argument but also gives some new support to the older view that overgrazing was a major contributive factor causing severe modern gullying.

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Invited papers given at a 1969 conference in Tucson, Arizona, jointly sponsored by AAAS and UNESCO on "Arid Lands in a Changing World." (A summary appeared in Nature and Resources 5(3): 7-12.)

Humphrey, R.R. 1958
An analysis of causes. Botanical Review 24(4): 193-252. (Reprinted as Arizona Agricultural Experiment Station Bulletin 299.)

Extensive portions of the desert grassland of southern Arizona, New Mexico and southwestern Texas have been invaded by woody species. Mesquite, creosote bush, cacti of the genus Opuntia, burroweed and snakeweed are among the principal invaders. The principal factors commonly believed to have caused this change are change of climate, grazing by domestic livestock, plant competition, rodents and fire. Of these various factors, change of climate seems to have had the least effect. Fires that were formerly frequent and widespread were the chief agency restricting shrub invasion. Since fires have been controlled, the introduction of domestic livestock, plant competition and rodents have been effective agents favoring woody plants at the expense of grasses.

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The rangelands of the western U.S. Scientific American 222(2): 88-96. GA 71C-1155. SWRA W70-04907.

Cattle grazing is the primary use of the rangelands of the western United States. The western ranges fall into three distinct categories: northern Rocky Mountains, intermountain and Southwest. True grassland is rare in the Southwest. Instead, deserts and semideserts predominate. Vegetation management is the major problem in improving the rangelands. Brush conversion programs have shown substantial increases in water yield in the treated areas. This is due to the fact that an acre of brush uses six more acre-inches of water than does herbaceous vegetation. With proper management of brush in the watersheds of the West, the land can provide more meat and lumber, suffer less from erosion and flood, and be more usable for recreation. The rapidly growing need for more recreational land is causing conflicts with other land uses. The advantages of brush control and the use of controlled fires, transhumance, canopy architecture, leaf-area index and exotic grasses are other topics discussed.

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A book intended for those seriously interested in planning, managing and executing research or development efforts in the arid world. It contains evaluative comments on the work accomplished in weather and climate, geomorphology and surface hydrology, surface materials, vegetation, fauna and desert coastal zones. Extensive bibliographies for each section.

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The topic of this series was addressed by several generalists speaking on its ecology, trends, causes; followed by several case studies to illustrate the theses advanced generally. These dealt with areas in Australia, eastern Oregon and southwestern Arizona and northwestern Mexico.

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Deserts on the march. 3rd ed., rev. University of Oklahoma Press, Norman. 178 p.

This popular account of man's misuse of the land and failure to understand its ecology centers around the historical development of land use in the United States. The cutting of forests, farming of cotton, plowing of prairies, polluting of rivers, overgrazing and general disregard for the welfare of the land are shown to be related to floods, mudslides, duststorms, erosion and natural calamities. The author argues that only through a broad ecological understanding of the environment and man's relationship to it coupled with moral commitment in the employment of technical resources and in our way of living will we be able to change our historic precedents.

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Briefly traces man's changing roles in the western U.S. Discusses food gathers, big game hunters, village farming life, villages and water sources, water control techniques, decline of village farming life, introduction of adaptable Athabascans, shift to wagework, collapse of Great Basin culture, rise and fall of the Sioux, adjustment to reservation life, Papago struggles in the desert, Indian adjustments and prospects. Climatic change in the 13th century was probably responsible for early decline of village farming life. Grazing abuses by Indians and whites have resulted in deteriorated rangelands. The plight of the Indian in the last century or so is not the result of environmental causes such as aridity; the causes are social. It can be seen as part of the worldwide problem of the non-literate, non-industrial world confronted by the technology and social and ethical systems of the western world. Indian techniques and their philosophy of working with the environment rather than against it may be indispensible ingredients for the successful utilization of arid lands.

APPENDIX B

A PARTIAL LIST OF U.S. AGENCY-SUPPORTED ACTIVITIES ASSOCIATED WITH DESERTIFICATION

I. U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)

A. Programs in the Sahel region include assistance to the Comite Permanent Interetats de Lutte contra la Secheresse dans le Sahel (CILSS) in planning its regional development program; establishing a water data collection and processing system for the Sahel Water Data Network; and developing national capabilities to control food crop pests throughout the Sahel.

B. Grants to institutions include one to the Florida Institute of Technology and another to the University of Arizona.

a. The Florida Institute of Technology is conducting a project entitled "Solar Cookers for Haiti: A Feasibility Study." Haiti's firewood and charcoal resources are becoming scarce as are those in other developing countries. The project consists of a review of solar cooker designs, evaluation of their compatibility with Haitian cooking requirements and preliminary design of a solar cooker appropriate to Haitian needs.

2. The University of Arizona was awarded a grant to strengthen its response capability in "Multiple Use Planning and Management of Natural Resources in Arid and Semiarid Developing Areas." The interdisciplinary faculty at the University of Arizona involved in the program is establishing linkages with institutions in developing arid and semiarid regions to promote service, training and research aimed at developing solutions to their problems.

C. USAID projects with specific countries are listed below.

1. Chad--The"Chad Range and Livestock Development" project will develop the manpower capability to implement a national range management program and, in the process, design a national range management plan. The project will include training in principles and practices of range management and a position on a national range and livestock planning commission.

2. Cameroon--The "North Cameroon Livestock and Agricultural Development" project involves regional development through resource management and will include a land use potentials inventory and development of range management practices, food crops and a livestock industry.

3. Ethiopia--A "Drought Rehabilitation and Development Strategy" project will guide government rehabilitation and development efforts in southern Ethiopia and will include aiding in the process of identifying proper donor assistance; studying and analyzing environmental, demographic and socioeconomic variables in Ethiopia; and formulating drought rehabilitation and development strategies for the southern lowlands.

4. Ghana--The "Developmental Applications of Science and Technology in Ghana" program administers a pilot research program on the problems of desertification in northeast Ghana which includes application of the experience and methods derived from the pilot study to two areas and an examination of mechanisms to establish research priorities.

5. Kenya--The "Survey of Semiarid and Marginal Lands" will include quantitative, narrative and graphic descriptions of the human and natural resources and existing infrastructure in the project area. Core problems that constrain development will be identified and delineated including population, migration patterns, erosion, desertification, water availability, deforestation, credit, production technology, marketing, extension, elements of agricultural education and institutional infrastructure along with the potential sociocultural constraints.

6. Mali--There are several projects with Malian institutions.

a. The "Land Use Capability Inventory" will provide guidance in national resource allocation through development of a 1: 200,000 map showing economic land classes and movement units and a tabular and narrative description of potentials and limitations of management units.

b. The "Mali Livestock Project" will test the vertical stratification of the livestock industry through range development, controlled grazing, post-season maintenance feeding, small-scale farm fattening and feedlot operations.

c. "Mali Livestock Sector Development" will initiate development of the Malian livestock sector through light development and management of the Dilly area (800,000 ha.), controlling the tsetse fly in a small area near Bamako, market development and training at all levels.

d. The "Mali Small Ruminant Survey" will determine the present position and appropriate place of sheep and goats in the Malian economy by surveying numbers, distribution, ownership and economic roles and by testing certain hypotheses of the role of sheep and goats in economic development.

e. The "Mali First Region Integrated Agricultural Production" project involves the western panhandle of Mali and should, with its successors, bring 13,800 sq. km. into ecological balance. Activities include a project allocation survey, developing a cropping system compatible with the environment and a program of grazing management.

f. The "Mali Operation Haute Vallee" will bring that portion of the Niger River bottom extending from just above Bamako to the Guinea border into ecologically balanced management through land-use condition and potentials survey, small-scale irrigation and village grazing and livestock programs.

7. Mauritania--Two projects in Mauritania are discussed below.

a. The "Mauritania 10th Region Development" program aims at optimizing ecological balance for economic endeavors, sustained livestock production and output and increased food supply in the region through a range and livestock management controlled demonstration, adaptive trials of soil and crop management, extension adoption of the new practices and grass fire control.

b. The "Mauritania Reforestation" project will improve the institutional condition of the national forest service and increase the supply of cooking fuel. Improved capability to manage the renewable resources of the public domain are likely to be emphasized as the project design proceeds.

8. Niger--The "Niger Range and Livestock Development" project will develop a pilot, controlled grazing program and a national grazing management system.

9. Senegal--There are two projects in Senegal.

a. The "Senegal Range and Livestock Project" is a pilot, integrated range management activity and will initiate a national resource management program through balanced grazing within defined boundaries, veterinary support, stock water development and salt, minerals and trace elements.

b. The "Senegal Land Conservation and Forestry" project will initiate a resource management program through the forest and wildlife program.

10. Upper Volta--The "Onchocerciasis-free Area Planning" project will develop an environmentally sound settlement plan for the "oncho-free" areas of Upper Volta and will include a land-use capabilities survey.

II. U.S. DEPARTMENT OF AGRICULTURE (USDA)

A. Wide-ranging research programs are discussed below.

1. Research directed toward classification procedures for range resources, formulating guidelines for predicting potentials and assessments of range responses to forage utilization regimes and vegetation manipulations alternatives is conducted at Tucson, Arizona.

2. Studies on the adaptation of plants to desert environments are conducted at the University of California, Riverside.

3. Methodology for the application of remote sensing to natural resources analyses is being developed at Tucson, Arizona.

B. Cold desert research programs are discussed below.

1. Research concerning ecology and management of salt desert shrub ranges is conducted at Provo, Utah.

2. Studies of shrub and tree improvement and culture for rehabilitation of wildlands is underway at Provo, Utah.

3. Investigations of ecology and management of pinon-juniper woodlands and associated shrub lands in the Great Basin are ongoing at Reno, Nevada.

C. Arid range research programs are discussed below.

1. Plants for arid range conditions are being selected at the Plant Materials Center, Los Lunas, New Mexico.

2. Mechanical treatment for establishing plants in arid ranges is being studied at the University of Arizona, Tucson.

3. Research aimed at selecting techniques and species for establishing range cover under arid conditions is being conducted at Tucson, Arizona at the Plant Materials Center.

D. Irrigated lands research includes a pilot project to determine ways to reduce best the saline drainage flows from irrigated lands into rivers, with return flow desalinization being the focus of this study at Wellton, Arizona.

E. Rehabilitation and Management Programs are discussed below.

1. Research directed toward developing methods for rehabilitating and managing mined spoils in the Southwest is conducted at Albuquerque, New Mexico.

2. Studies to promote reestablishment of plants, animals and hydrologic stability on surface mine spoils and water impoundments in the northern Great Plains are underway at Rapid City, South Dakota.

3. Investigations to develop methods for rehabilitating and managing mined spoils in the Intermountain and northern Rocky Mountains regions are ongoing at Logan, Utah.

III. ENVIRONMENTAL PROTECTION AGENCY (EPA)

A. Wide-ranging research activities are discussed below.

1. A cooperative research project with Egyptian institutions will assess the environmental and health consequences of the Aswan High Dam.

2. A desert biome study with the University of Alexandria (Egypt) utilizes modeling techniques to predict responses should certain events occur such as deforestation or reforestation.

3. Arid lands research projects are underway in portions of the western United States.

B. Specific animal and irrigated crop production environmental assessment projects are being conducted in both India and Pakistan.

1. Research is underway to develop management tools to dispose of animal wastes resulting from a production of animals and poultry in an environmentally safe manner.

2. Methods are being developed to control the quality of irrigation return flow along with investigating the bio-engineering aspects of agricultural drainage.

IV. U.S. GEOLOGICAL SURVEY (USGS)

A. LANDSAT research activities are outlined below.

1. General applications of LANDSAT imagery are discussed in the following sections.

a. Methods are being developed for terrain description and monitoring utilizing the Australian land systems research approach. Present experiments in Queensland, Australia will be continued in the western United States. The mapping system is an integrated system in which soils, vegetations and geomorphic features are combined into single mapping and land management units.

b. Methods of flood mapping with LANDSAT images are being researched which are particularly applicable to determination of flooded areas in arid and semiarid regions and which have potential for identifying recharge areas of both surface and deep aquifers.

c. A prime example of the use of LANDSAT images in desert regions on a worldwide basis is a project entitled "Sand Seas of the World," although it is not specifically an Earth Resources Orbiting Satellite project.

2. A regional LANDSAT program involves the impact of strip mining on range resources and wildlife habitat. The environmental impact analysis is using LANDSAT and aerial data in southeastern Idaho, but techniques and methods are transferable on a worldwide basis.

B. Two "Training in Remote Sensing Applications" courses for international students are given each year with the goal of teaching remote sensing data interpretative techniques. Other specific courses in various disciplines are given or requested. Courses can be tailored to address specifically land cover and other mapping of desert regions.

C. Two research programs focus on mineral wastes.

1. Stabilization of mineral wastes research aims to develop new or improved methods of stabilizing and/or reclaiming mined lands and mineral waste piles. Six field test sites which have either arid or semiarid climates are located in the states of Arizona, Colorado, Utah, Washington and Wyoming. Testing has been done on wastes from mining and/or processing copper, lead, zinc, uranium and asbestos.

2. Research on purification and conservation of mineral processing wastewaters seeks to develop effective methods of decontaminating metallurgical wastewaters for process reuse or for discharge. Recycling of process wastewaters is particularly important in regions having either arid or semiarid climates.

D. Several projects address arid and semiarid lands vegetation.

1. Studies of desert shrub ecology and utilization of soil moisture under high moisture stresses are being conducted.

2. Many aspects of the "Gila River Phreatophyte Project" have worldwide applications, especially the use of remote sensing in monitoring water use by vegetation and analysis of evapotranspiration.

3. An analysis of soil moisture data from sampling desert ecosystems to estimate evapotranspiration led to the discovery that the greatest reduction in available soil moisture was in desert grassland rather than oak woodland.

4. A study of saguaro populations in the Arizona desert is being conducted to determine causes for fluctuations in plant establishment. Climate, disease and man's activities are being investigated.

5. Abandoned agricultural land in the Tucson-Phoenix (Arizona) area is being studied to determine the rate of reestablishment of native vegetation species. The fields have been abandoned for about 40 years.

E. Hydrology research is also being conducted.

1. A study of grazing patterns aims to determine their effects on runoff and sediment yield in salt desert shrub terrain. The study site is in western Colorado.

2. The effects on arid lands hydrology of converting vegetation cover from woody shrubs to grassland are being investigated.

3. Another study involves assessing the effects of mechanical land treatments such as contour furrowing, pitting and ripping on hydrology including runoff, soil moisture availability and plant communities.

V. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

A. NOAA participates with the National Center for Atmospheric Research (NCAR) and the U.S. Air Force Environmental Technical Applications Center (ETAC) in extending the global inventory of existing climatic data.

1. Analyzed and observed data from the National Meteorological Center (NMC) flow into NOAA's National Climatological Center (NCC).

2. Similar data from the Air Force Global Weather Central go to ETAC and subsequently to NCC, where it becomes part of a common poll of global meteorological data. NCAR, using data from NCC and other sources, reformulates the data in ways convenient for research purposes, archives it and makes it available as a service to members of the research community. (A July 1975 NCAR report, "Data Sets for Meteorological Research," describes the types of data made available through the efforts of these three organizations.)

B. Long-range predictions and satellite programs within NOAA furnish a starting base for a climate diagnostic activity.

1. The National Weather Service (NWS/NMC) long-range prediction program includes necessary analyses with diagnostic studies as circumstances permit. Data sets are generated which extend back over the useful history of data used.

2. NMC ongoing programs include the study of year-to-year fluctuations in the stratospheric circulation, analyses of stratospheric warming and calculation of selected parameters related to the global stratospheric energy budget. Interrelationship between stratospheric and tropospheric circulations is explored.

3. NMC maintains a 30-day field of global weather data which, with similar data from the National Environmental Satellite Service (NESS), is the present source for compiling current climatic data sets.

4. NMC is compiling, for the Environmental Data Service Center for Climatic and Environmental Assessment (CCEA) and the NWS Agricultural Weather Service Office (AWSO), weekly extracts of the most elementary climatic parameters needed to assess current climatic and crop conditions over the world's major agricultural areas.

5. NWS AWSO, in cooperation with the U.S. Department of Agriculture (USDA), analyzes and publishes the previous week's weather and crop conditions in the U.S. A monthly summary for major foreign agricultural areas is included (although monthly climatic data from many areas are incomplete).

6. To the extent limited resources permit, CCEA is developing experimental crop yield models and is participating in the NASA/USDA/NOAA effort termed "Large Area Crop Inventory Experiment" (LACIE) to develop grain production forecasts. Current and potential applications include providing timely and early warning crop alerts, fresh water supply estimates and crop yields.

7. NESS prepares on an operational basis global charts of monthly and seasonal values of radiative heat budget and monthly and seasonal resultant wind fields at 200 and 700 millibars and their anomalies.

8. NESS is studying interrelations of cloudiness and circulation over large space and time scales.

9. NESS applies satellite imaging for detecting, measuring and mapping mean monthly winter snow cover over the Northern Hemisphere and is experimenting with snowfall prediction methods for North American and Eurasian winter months.

10. The Air Resources Laboratory (ARL) is examining variations in sunshine amount, total ozone and tropospheric temperature changes as part of a continuing investigation into climatic trends during the last few decades.

11. The Geophysical Fluid Dynamics Laboratory (GFDL) is investigating the sensitivity and stability of climate models to such external variables as the solar constant and atmospheric carbon dioxide to assess the value of using simple models in climate studies.

C. NOAA Experimental Research Laboratories conduct cloud seeding experiments in cumulus clouds over southern Florida for the purpose of inducing the merger and growth of cumulus towers developing in proximity to one another thereby increasing precipitation from the larger cloud system and hopefully increasing net precipitation over a large target area. The technique once proven may have a potential application in semiarid regions when appropriate clouds occur; although successful transfer of the massive or dynamic seeding approach used in Florida to drought areas is unlikely.

D. NOAA administers the World Weather Watch Voluntary Assistance Program for the Department of State. These funds:

1. Provide radio transmitting and receiving equipment to developing countries to improve national and international meteorological data exchange.

2. Provide wind-finding radar to tropical area countries.

3. Supply direct readout equipment to provide a capability for intercepting processed data from the GOES system.

4. Provide long-term and short-term fellowships to meteorologists in developing countries to increase their capability to use modern equipment and to improve their understanding of atmospheric processes that result in eventual, long-range weather and climate change.

5. Support international efforts under the Global Atmospheric Research Program (GARP) to define the research required to advance knowledge on the physical basis of climate and climatic fluctuations.

E. Understanding the physical basis of climate is the "second" objective of GARP. NOAA is contributing directly to GARP by:

1. Processing, analyzing and archiving atmospheric and oceanographic data.

2. Developing mathematical models and data management systems.

3. Specifying, developing and procuring special observing systems.

4. Conducting fundamental investigations of the dynamics of geophysical fluids, the atmosphere, the hydrosphere and the cryosphere over a wide range of time and space scales.

5. Expanding research efforts on cause-and-effect relationships between climate and atmospheric pollutants.

6. Conducting a comprehensive program to develop ground-based techniques for remote measurement of critical meteorological and oceanographic parameters.

F. NOAA input into the World Weather Watch (WWW) will impact on the United Nations Environment Program EARTHWATCH since the Global Environment Monitoring System (GEMS), the monitoring segment of EARTHWATCH, will make use of the observing, processing and telecommunicating systems of WWW.

VI. NATIONAL SCIENCE FOUNDATION (NSF)

A. "Analysis of Structure and Function of Desert Ecosystems" has as its goal elucidation of patterns and magnitude of accumulation and transfer of biologically important resources such as water, nutrients and energy; discovery and quantification of mechanisms by which those processes are limited or augmented; modeling the system conceptually and mathematically; and advancement of the base of ecosystem theory and aid in making management decisions about renewable natural resources.

B. "Structure, Function and Utilization of Grassland Ecosystems" will model the ecosystem; improve ecosystem theory; understand the biomass, trophic structure, water, nutrient and energy flow; and utilize and synthesize the results.

C. "African Climate During the Last Ice Age" is designed to test the hypothesis that East Africa was dry during the height of the the last temperate glaciation; examine the movement of the convergence zone between the dry Sahara Harmattan and cooler, moist air flows off the Gulf of Guinea; and understand the fundamental nature of global climate change using East African lake cores.

D. Research about "Aerosol Transport over the Equatorial North Atlantic Ocean as Related to Weather, Climate and Land Use in North Africa" will establish an aerosol and atmospheric turbidity network across the equatorial North Atlantic for monitoring the aerosol output of North Africa; identify source areas, determine if increased aerosol output is derived from normally arid and/or desert use practices; measure the time required for soils to become stabilized against wind erosion once rains return to normal; and measure mass transport of mineral aerosols to the ocean.

E. "Dynamics of Large-Scale Atmosphere and Oceanic Processes" research is a model study of the Sahelian region indicting that feedbacks from the ground creates weather patterns that reinforce and accentuate the arid or desert region.

Other NSF research includes "Formation of Deserts," "Midwestern Drought Indices and Drought Cycles Using Sea-Surface Temperature Anomalies from the Pacific," "Frequency and Power Spectral Analysis of Drought Cycles," "Arid Land Climate Patterns," "Southwestern U.S. Deserts and Their Similarity with African Weather and Climate," "Bovine Adaptation to Desert Environments Focusing on North Africa," "Adaptation of Large Mammals to the Sahara," "General Dynamics of Arid Land Ecosystems."

Also "Ways in Which Disparate Organisms Evolved in the Desert," "Management of Environmental Systems to Prevent Desertification," "Studies of Nomadism," "Relationship Between Drought and Grazing Patterns," "Ancient Social Adaptation," "Hunting and Gaming Practices in Botswana and the Kalahari," "Social and Biological Anthropology in the Kalahari," "Drought and Population Resettlement in the American Southwest," and "Bedouin Use of Surface Water, Grazing, etc., in Northern Arabia."

APPENDIX C

Spanish Summary

Introducción

La presente es para indicar el estado del problema de desertificación en los Estados Unidos. Se incluye un resumen histórico sobre los problemas del use de tierras en las zonas áridas y semi-áridas de los Estados Unidos, se discute algunos de los problemas actuales, y se delinea la necesidad de planeamiento y manejo racional de tierras en Norteamerica. La desertificación no es un problema solo para los países en desarollo. Es un problema qué el mundo entero tiene qué combatir. Norteamerica comparte en este problema, puede ofrecer soluciones, y sin duda beneficiará del intercambio de ideas y metodologías qué serán presentadas durante y despúes de la Conferencia de Desertificación de las Naciones Unidas.

Una sequía qué duro varios meses en la Reservación de los Indios Papago en Arizona ocasionó fondos y servicios de emergencía de varias agencias federales, y causó severas perdidas de ganado y cultivos. Los programas de reclamación de tierras y la asistencia a las reservaciones Indias han alcanzado a los billones de dolares--y tanto los beneficios como los gastos tienen ramificaciones nacionales. Con la posible excepción de algunos de los usos de recreación, se deberá acentuar qué la experiencia nortecamericana sobre la desertificación será pertinente y aplicable a otras zonas áridas y semi-áridas del mundo.

Historia

Se han utilizado las tierras áridas y semi-áridas en Norteamerica durante los últimos 11,000 años, y quizás mas, con el cultivo ocurriendo hace 6,000 años. Hasta el siglo XIX, la tenencia de tierra fué el problema principal en Norteamerica. Acción por parte del Congreso de los Estados Unidos trató de establecer controles sobre pastoreo, pero hasta hoy día el control científico del pasturaje se complica par el uso multiple y las numerosas acciones legales referentes a la propiedad y arrendamiento de tierras.

Pasturaje

La mayoría de los especialistas sobre el control científico del pasturaje están de acuerdo que´ muchas tierras publicas (federales) y privadas se están degradando, y qué se deberían aumentar los controles. Hay muchos casos bien documentados en los Estados Unidos en los cuales el sobre-pastoreo causó la invasión de arbustos pequeños de poco valor nutritivo, la aceleración del proceso de erosión, y el agotamiento de aguas subterraneas.

Agricultura de Riego

El riego ha transformado literalmente muchas partes de los desiertos del suroeste árido de los Estados Unidos en centros de producción agricola. Pero el riego ha contribuido al proceso de desertificación debido al consumo de agua, salinización del suelo, y a veces el abandonamiento de estas tierras agricolas y su conversación a tierras estériles sin utilidad.

Minería

Aunque sus efectos no son extensivos en area, la minería puede practicamente crear un desierto local.

Urbanización

La urbanización puede ser uno de los mejores usos para las tierras áridas y semi-áridas, con tal de que´ el buen manejo y el sentido común se use en cada caso. Aunque el mal uso de aguas urbanas podría resultar en "ciudades fantasmas" y desiertos de concreto, los problemas qué mas se comentan son causados por los comerciantes de tierras, quienes subdividen el desierto, construyen "calles," y tratan de vender terrenos áridos a personas crédulas. Centenares de estas "calles" sin pavimiento cruzan los desiertos de Arizona, Nueva Mexico, y Nevada, sin ningún edificio visible, y se convierten en arroyos, los cuales destruyen las capas superficiales del suelo.

Recreación

Debido al sol en las regiones áridas, el buen ingreso del trabajador americano, y mas tiempo para el recreo, se ha creado un problema de degradación de tierras tanto fastidioso como interesante. Motocicletas, jips de cuatro-tracción, y otros vehículos de recreo han invadido el desierto y han dejado sus marcas.

Freatofitas y Otros Controles de Vegetación

Muchos de los arboles qué se encuentran al borde de los ríos y arroyos, y qué consumen mucho agua, las freatofitas, debrían, en la opinion de algunos, ser eliminados en ciertos lugares. También se ha sugerido la eliminación de vegetación de millones de acres de bosque y desierto en Arizona, para incrementar el drenaje de aguas. Tales planes, sinembargo, podrían tener consequencias serias al largo plazo en cuanto al potencial de desertificación. Al corto plazo, incrementando el drenaje de agua por medio de la eliminación de vegetación representará menos agua infiltrandose a las aguas subterraneas, y sedimento se accumulará mas rapidamente en las cuencas de captación.

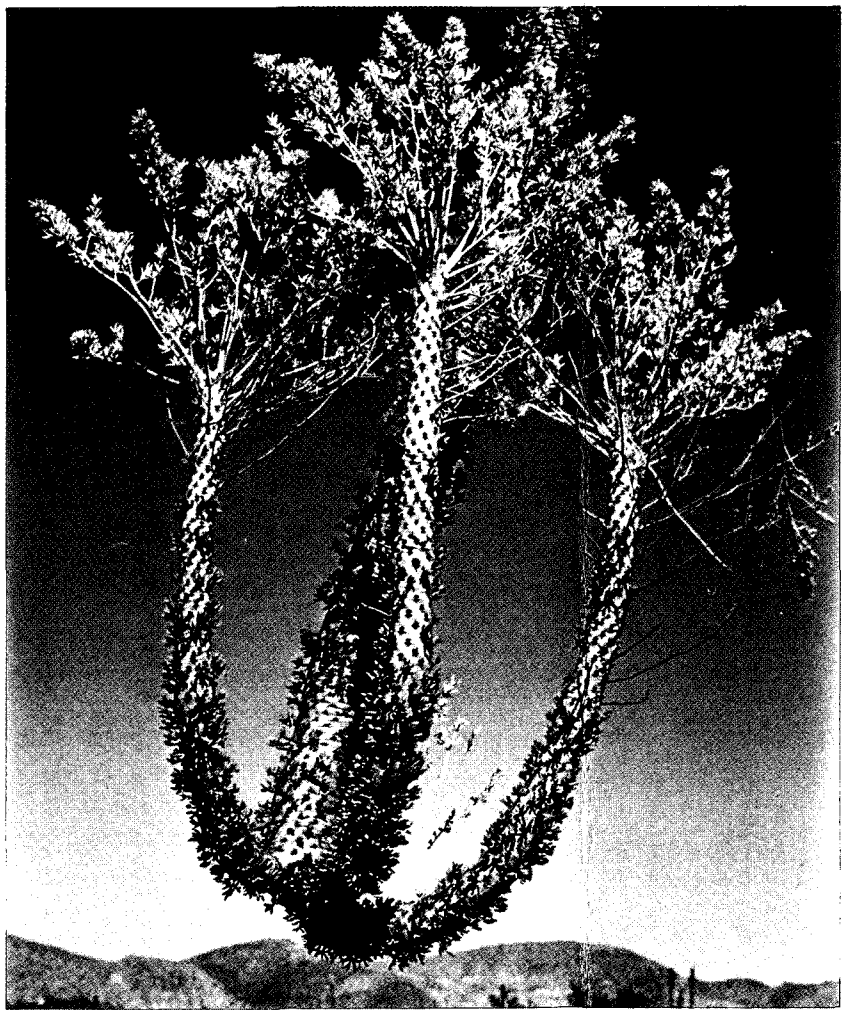
Resumen

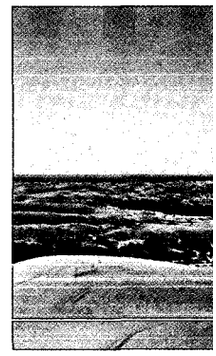
Aunque la palabra "desertificación" es relativemente nueva en el vocabulario científico inglés, el mal uso de la tierra y los recursos naturales no es nuevo. La desertificación es realmente un problema serio; entre otros, los factores contribuyentes son: sobre-pastoreo, salinización de los suelos, agotamiento de recursos de agua, presiones de población, abandonamiento de tierras, algunas actividades mineras, y la destrucción de la superficie del desierto por vehículos de recreo.

Sería un error ignorar las consequencias de la desertificación en los Estados Unidos. Mientras que la alta tecnología americana tiene gran capacidad de producción, tiene igualmente gran capacidad de destrucción. Si los planificadores y administradores de recursos naturales, los intereses privados, y las agencias federales de regulación no mantienen vigilancia sobre la degradación de tierras en el suroeste, la desertificación podría llegar a tener repercusiones nacionales de serias proporciones. Tenemos el conocimiento técnico para controlar, y en ciertos casos, hasta reversar la degradación de tierras. Sinembargo, las presiones de una población que está creciendo demasiado rápido, como en muchos otros países, junto con los problemas sociales relaciondandos con la aplicación de la tecnología conocida, no permiten un optimismo sin cautela.

THE UNIVERSITY OF ARIZONA

ARID LANDS RESEARCH



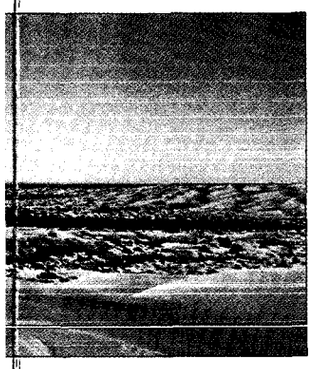


Cover Photo

Seemingly growing from space, this boojum (Idria columnaris), *photographed near the site of the former San Fernando Mission in central Baja California, is characteristic of a droop that often occurs after maturity, possibly during periods of drought when the cells are less turgid and the total structure thus weaker. In this instance, either prior or subsequent to drooping, the end of the original main stem was broken off and several new stems developed. These latter, in contrast with the slender side branches, always grow upward, as these are doing. Flowers typically occur near the ends of the main stems as they have here. Blossoming occurs in mid-summer, after which the seeds ripen until they are shed in the fall. This photograph shows these ripening seeds.*

R. R. Humphrey

The primitive sun symbol appearing on the title page, opposit is internationally recognized as the colophon of the Universi of Arizona's Office of Arid Land Studies. Similar renditions b desert-dwelling man of five continents reflect his historic pr occupation and dependence upon the sun.



G. Donald Kucera

Dune field, extreme southern portion of the Gran Desierto, northwestern Sonora, taken from the southern Pinacates looking west toward the Sea of Cortez.

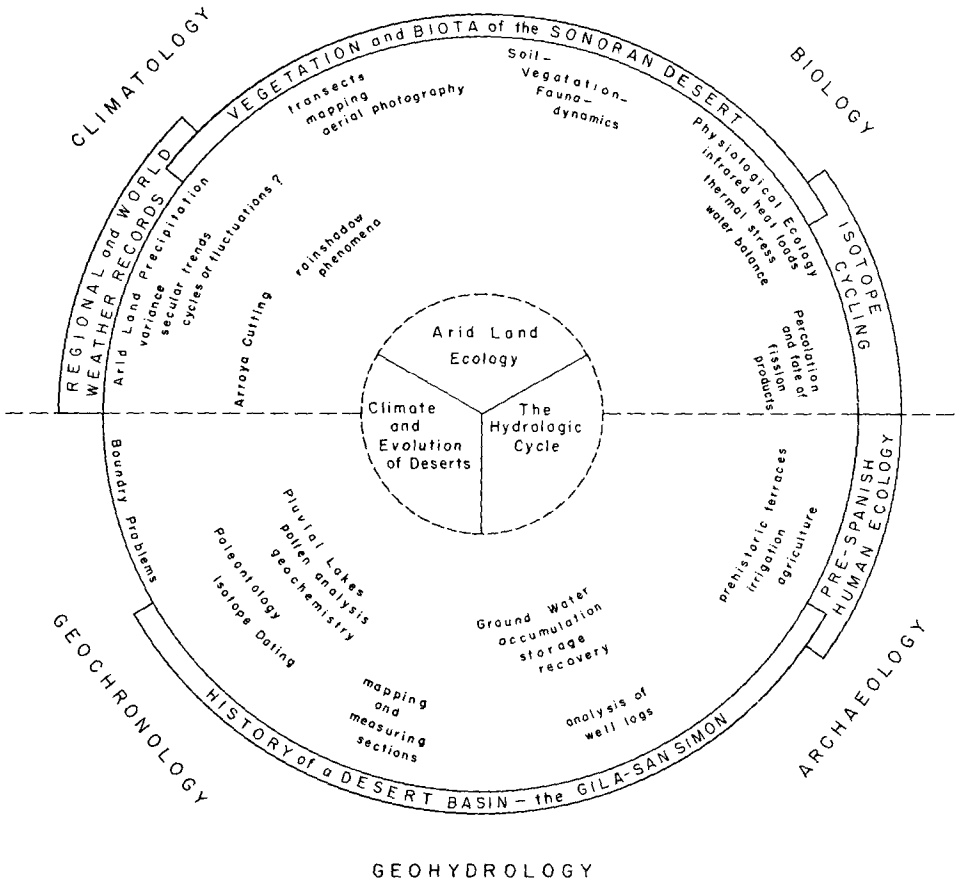
Arid Lands Research at the University of Arizona

Text by Patricia Paylore

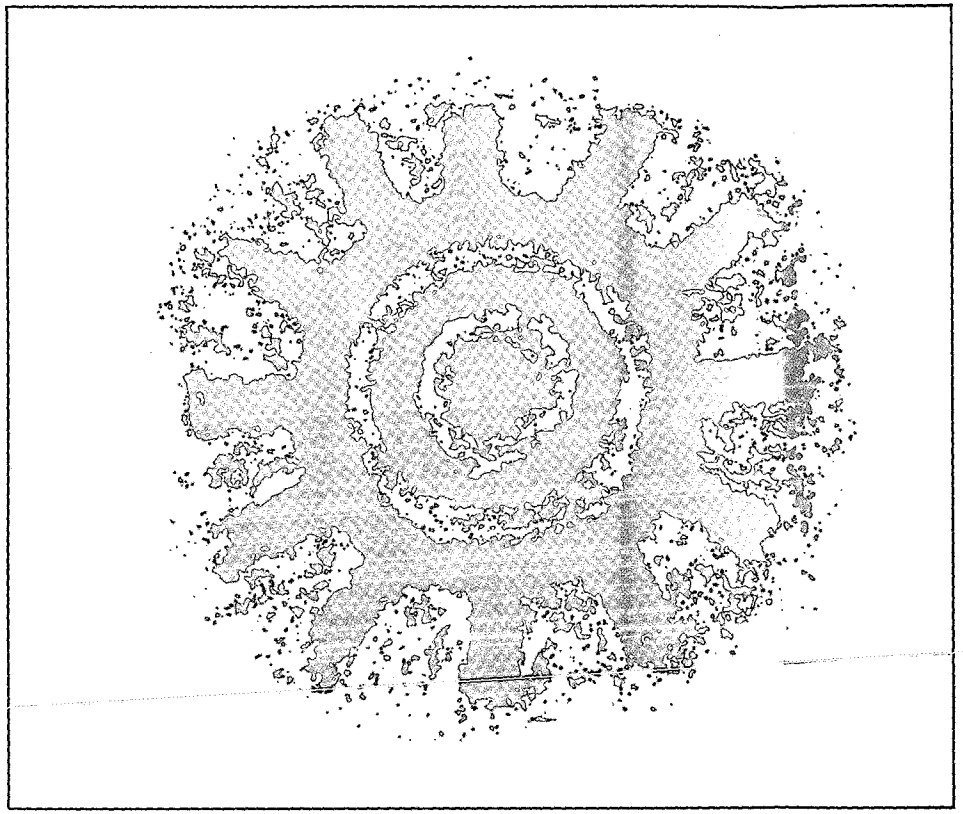
Situated as it is on the edge of the Sonoran Desert, the University of Arizona forms a great research matrix of arid lands investigations. Its traditional commitment to this purpose is evident in its dedication to the needs of the state, in its scholarship, in its publications, in the intellectual accomplishments of its faculties and students, in the leadership it has exerted throughout the arid world in such fields as greenhouse agriculture, desert ecology, anthropology, water resources development, crop production and plant breeding. To select only these, however, is to do a disservice to the numerous other agencies of the University whose total contributions to arid lands research make it a truly multidisciplinary fulfillment of an historic obligation. In what follows, then, we set forth the dynamics of the University's present position, trusting that such an overview may be the instrument by which you will arrive at a better understanding of this arid lands design.

R. R. Humphrey

Reflection of an ocotillo (Fouquieria splendens) *in an intermittent canyon stream on the lower west-facing slope of the Rincon Mountains, east of Tucson. This odd conspicuous plant illustrates adaptive mechanisms that allow it to drop its leaves as soon as the soil dries but as quickly refoliate after a good rain. Cuttings, which root readily, are commonly used throughout the Sonoran Desert for living fences and ramadas.*



ARID LANDS RESEARCH



THE UNIVERSITY OF ARIZONA

Man in the Desert

The extraordinary attraction that the world's deserts have had for man immemorially has accelerated in modern times, as he seeks refuge from other environments more crowded, more ugly, less satisfying, less pleasurable. From its founding, the University of Arizona has devoted its energies to making Arizona itself more habitable. Now well into the second half of its first century, the University recognizes its obligations beyond immediacy — to make sure that the arid land to which most of us came from elsewhere retains those qualities which brought us here.

Ancient Man in an Arid Land:

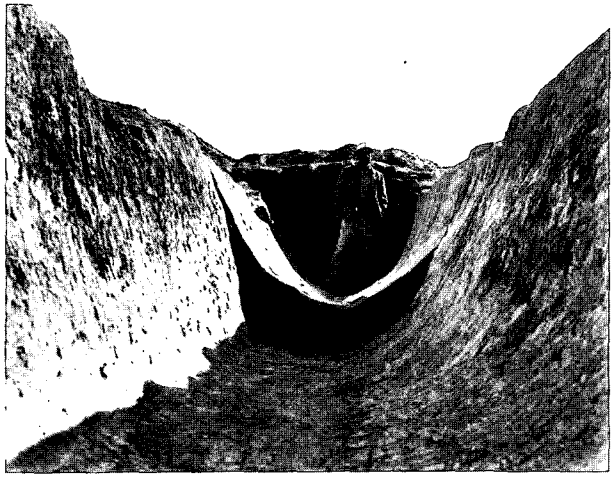
Ancient man solved on a primitive level many of the environmental problems that persist more critically for our highly technological contemporary society. When he brought water by canals to his fields, he was able to create a stable society in a region of relatively limited resources, supported by land-use patterns designed to mitigate the restrictions of adverse climatic conditions.

The University of Arizona through its **Department of Anthropology** and the **Arizona State Museum** has uncovered through several generations of research a knowledge and understanding of those earlier civilizations that went before us, not only here in the familiar southwest but in similar environments in the Near East, Africa, Mexico. Related research in **dendrochronology, palynology,** and the **geosciences** is being merged to provide us with the most complete picture possible of our arid lands predecessor, and how he managed, or, ultimately, failed to manage his environment. Field work at sites throughout Arizona and northern Mexico supports the laboratory findings, and the comprehensive academic program helps interpret the evidence.

The Physiology of Adaptation:

The total environment in which the university operates provides an unusual laboratory for the development of arid lands-oriented research. The **College of Medicine** is directing attention to the problems of thermal stress on human physiology, while the **Department of Psychology**, in a new program designed to parallel this, is emphasizing studies on the environmental psychology of living in an arid land and the relationship between psychological processes and the large-scale environment. In the **College of Agriculture** an interdisciplinary graduate program relates to the effects of high climatic temperatures on livestock and their productivity. Further studies on hormonal changes in people working outdoors in high temperatures, the effect of heat on reproductive processes, the effect of arid soil-borne organisms on humans and animals, and the comparative psychology of indigenous populations in various arid regions of the world are all avenues of exploration to be undertaken here by interacting teams from **medicine, engineering, architecture,** and others.

Atmospheric Sciences is developing research in bioclimatology where the dynamic interaction of climate, plants, and man is shown in the context of those special micrometeorological and hydrometeorological conditions peculiar to arid lands. In



Arizona State Museum, Helga Teiwes-French

View along excavated 14th century irrigation canal at Snaketown, a prehistoric Hohokam community in south-central Arizona. Dr. Emil W. Haury, excavator of the site, stands on the latest of four superimposed canal surfaces. This canal is part of an extensive irrigation system that began about 300 BC in the desert valleys of the Gila and Salt Rivers near present-day Phoenix, Arizona.

Arizona State Museum, Helga Teiwes-French

Although the Hohokam depended mainly on rivers and canals for domestic water, they also exploited groundwater in favorable spots by digging wells. These were of two types: a conventional tube-like well and a walk-in well which had a large diameter at ground level, tapering to a small diameter at the water table. In time, these wells were abandoned and the holes became convenient places for dumping refuse. In the Snaketown picture here, the deposits in one of these walk-in wells has been sectioned preparatory to the stratigraphic removal of the contained cultural materials.

Engineering, such relatively new concepts as bioengineering and biomechanics are being harnessed to probe the relation between medicine and engineering, with emphasis on such topics as cardiovascular dynamics, body fluid and renal physiology, isotopes and radiation, and solid state electronics in biology and medicine, all of which are directly affected by aridity. In the **Biological Sciences,** the University is seeking answers to survival and adaptation in an arid climate from the behavior of desert-dwelling animals and plants.

Social Institutions:

The physical and biological environment of the arid lands requires an unusual degree of comprehension on the part of desert-dwelling man, if he is to appreciate its unique qualities, use them to improve the ambience of his own life, and leave behind him for the future as much of his inheritance as he can. To achieve this, he must depend on his institutions to guide him, educate him, enlarge his understanding of his special environment. In turn, these same institutions will depend upon him to devote his creativity, his skills, and his invention to those aspects of education by which we endure and broaden.

In a university atmosphere we should find the ideal juxtaposition of these lines. Here we seek through studies in **Political Science, Economics,** the **Law, Anthropology,** to relate man's best instincts to his dominant role in any environment, but especially in the arid regions where the risk of failure is the more visible. The role of government in the management of energy, natural resources, and the environment, for example, is studied in the course in "Environmental Policy," where process and policy alternatives with special reference to the arid southwest are reviewed. The role of **Agriculture** in economic growth and development, including economic policies related to arid lands agriculture and to world trade in agricultural commodities, is examined in courses in international rural economic development and natural resources economics.

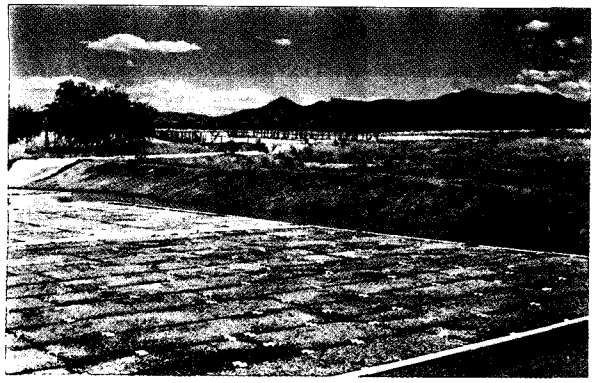
In **Architecture,** the University is exploring relationships between the built environment and the unique characteristics of the natural arid land environment. Lessons of earlier indigenous architecture are being re-examined to discover the implications for our contemporary energy-short society. Students in this field are challenged to think creatively in the search for new methods of achieving functional efficiency, structural simplicity, and environmental harmony in arid lands architecture. Consideration of solar energy systems, natural means of cooling and heating, indigenous landscape applications, insulative construction, orientation, and other needs should result in the development of a more appropriate aesthetic expression and community design for arid lands architecture. Architecture's "zero energy house," an autonomous living unit, provides actual student experience in the requirements for substitute sources of energy, including solar stills, sun shields, and mechanisms for the recycling of wastes.

Planning for the Future:

While it is possible to say that such technological amenities as air-conditioning, artificial lakes for recreation, even the mobility that our automobiles afford us, have allowed us to adapt to an arid environment, or to escape it, according to our needs, nevertheless a university has an obligation to help society plan in far-reaching ways,

The University of Arizona is prepared to offer these assets wherever needed, believing that the development of vast arid regions of the world will succeed to the degree that it is attempted in such a framework of understanding of the dynamics of aridity. These are often subtle unobserved forces. To direct them intelligently, here and elsewhere, can be achieved through such programs as are being pioneered here.

Natural Resources



C. B. Cluff

In the multipurpose water harvesting system demonstrated here, wine grapes have been planted in the channels of the shaped compacted earth catchment. Excess water is collected in a sodium-treated raft-covered tank to prevent seepage and evaporation. The rafts are constructed with coupled, expanded polystyrene panels, coated with asphalt and chips. Cooperating departments: ***Soils, Water, and Engineering*** *and the* ***Water Resources Research Center.***

beyond our immediate convenience and comfort, to insure long-term environmental quality and conservation. With proper planning by attention to certain functional aspects of arid lands habitation, it is possible to minimize social conflicts deriving from poor planning, and turn them instead into acceptable, even pleasurable, interactive contacts.

To these ends, other University departments than Architecture are pooling their competence, notably **Civil Engineering** in courses in land development and water resources engineering, **Systems and Industrial Engineering** and **Aerospace and Mechanical Engineering** in courses in environmental engineering analyzing and designing systems and components for control of temperature, air distribution, air cleanliness, and acoustics in building space in warm climates. The use of solar energy is contingent upon engineering research, to which much attention is being given here in an area of abundant solar heat, specifically through experimental designs for its use in both private dwellings and industrial buildings, as well as for the generation of electrical power, exemplifying how the stimulus of crisis can challenge students to think innovatively.

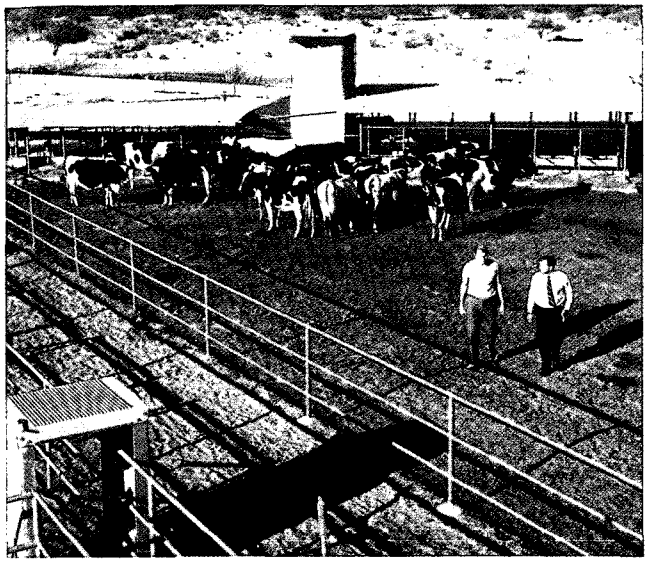
Water:

Water resources, their use and conservation, have been the classic concern of the University since its beginnings. Today, no less than earlier, much of its focus in the field of natural resources is on the groundwater and surface water available, its quality, ways of using it and conserving it for those needs most urgent, and methods of augmenting a diminishing and insufficient supply.

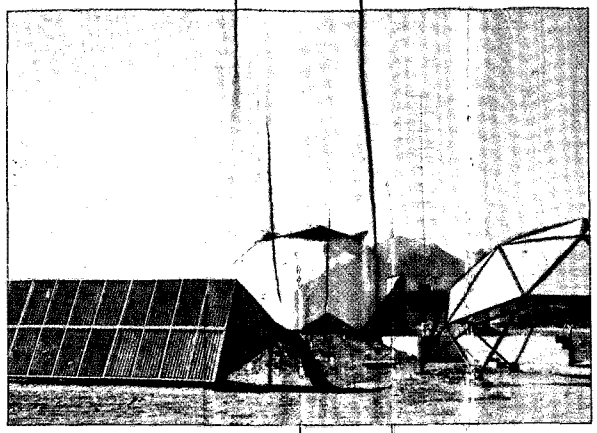
To the execution of these purposes, departments such as **Hydrology and Water Resources, Soils, Water, and Engineering, Civil Engineering,** and the **Water Resources Research Center** and the **School of Renewable Natural Resources** are devoting their skills and experience. Such courses in water resources administration as "Water, Society, and the Environment," for example, deal with the role of behavioral sciences (social, legal, economic, political, and psychological) in the public administration of the use, development, and management of water resources, and the ecological relation of water in the biosphere.

The **Water Resources Research Center** deploys its staff and associated personnel, including graduate students, in research into such problems as the harvesting of additional water from arid and semiarid watersheds, artificial recharging of groundwater aquifers, evaporation suppression, and systems modeling.

Changes in desert agriculture resulting from increased costs and shortages of associated energy needs are being studied by the Department of **Soils, Water, and Engineering.** Courses on and research into the need to manage salt-affected soils, an arid lands problem of world-wide proportions, deal with diagnostic procedures for evaluating soil-water-plant relationships, reclamation, and the economics of irrigation project development. Drainage of irrigated lands, desert strip farming, reservoir engineering, erosion, and flood control are other facets of the interaction of water and the land, as we extend our traditional preoccupation with water to the management of arid lands in general.

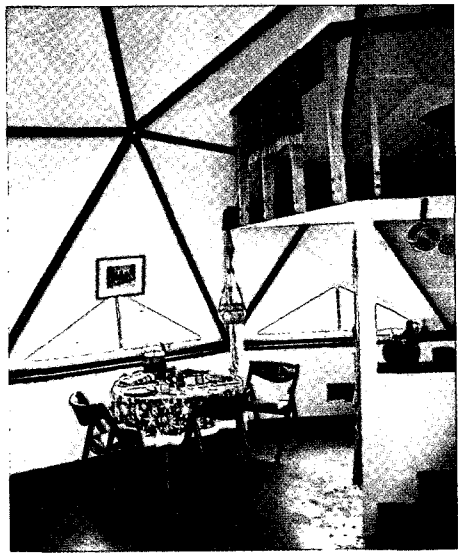


After a decade of research into ways of overcoming problems of heat stress in dairy cows, University research in the College of Agriculture demonstrates increased milk flow and calf production through use of evaporative coolers installed in corral shelters.



Prof. Alvin E. Miller

Autonomous Living Unit Number 2, designed and constructed by advanced Architecture students, is a highly portable low-cost housing unit, independent of external systems, relying on solar energy, energy storage, and other techniques for its self-sufficiency. Experience gained from ALU-2 is also being used to develop more advanced systems by the ***College of Architecture.***



Prof. Alvin E. Miller

Interior of Autonomous Living Unit Number 2

Arizona State Museum, Helga Teiwes-French

Governor Alexander Lewis, Sr., Gila River Pima-Maricopa Indian Community, south-central Arizona, where the University's ***Bureau of Ethnic Research*** *is assisting in developing a plan for more effective tribal government and management.*

G. Donald Kucera

We can no longer afford to scoff at the simple generation of wind power by the familiar windmill, visible throughout the western prairies of the last century. Despite the fact that it ranks far below solar radiation as a continuously available resource (a ratio of 740 to 5, in units of current U.S. rate of energy consumption), and that its scientific feasibility, costs, and hazards have not yet been determined, the potential of wind power is undergoing scientific examination. Meantime, in isolated desert locations such as this one near Tule Well, Cabeza Prieta, extreme southwestern Arizona, it serves well the desert bighorn sheep (Ovis canadensis) *population of this game refuge by pumping water during long periods of drought.*

For example, scientists in the Department of **Plant Sciences** are asking: Can economic plants be improved so that they will produce more useable dry matter while using less water? and to answer, are conducting pioneering research in efforts to determine if ways can be found to assure more efficient use of water by crop plants. Our plant breeders have made great strides in developing varieties with high yields, insect and disease resistance, plant uniformity and other desirable characteristics. Similar progress in improving water-use efficiency seems entirely possible.

The University's research in these areas has had an incalculable influence on the **agriculture** of Arizona for over eighty years, and its focus during the next eighty will reflect the region's continuing need to redirect its energies in new and innovative ways that will keep pace with a changing dynamic society.

Watersheds/Waterways:

So closely related to the overall focus on water in general as to be almost indistinguishable are studies relating to Water Management. Watershed hydrology, forest resource economics, autecology/synecology dealing with the relationships between organisms and biological communities and their environments, all affect the arid lands that lie below our watersheds and contribute to the surface water flow that comprises our streams, ephemeral or perennial. Our understanding of these processes constitutes one of the University's lodestars, as we combine these tasks with others relating to fisheries management, recreation resource planning, and natural resources conservation.

Minerals/Energy:

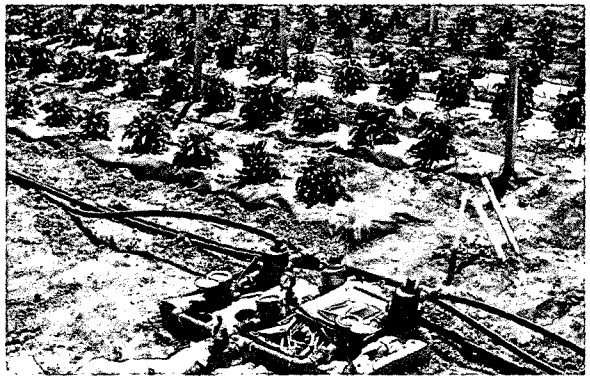
Arizona, largely arid and semiarid, possesses a wealth of mineral and other energy sources: solar, wind, geothermal, hydro, fossil. The exploration of these resources has been a characteristic of the University's dedication to the needs of the State since its founding, and the increasingly sophisticated technology it is now able to employ in these areas will continue to place these considerations in the fore of its total commitments. The Laboratory of **Isotope Geochemistry,** for example, applies radioactive dating techniques for the correlation of geologic events and trace element geochemistry. Much of its work has centered around the evolution of Basin-and-Range and Colorado Plateau physiographic features, and the use of isotope hydrology studies in the interpretation and analysis of dynamic groundwater problems.

Arizona, at a crossroad of interest in natural resources, may be looked upon as a prototype of similar environments because of a number of factors: its aridity demands keener understanding of groundwater geology; the growing hunger for energy requires research into the area's petroleum, coal, geothermal, and nuclear fuel capabilities; a growing urban complex calls for planning and understanding of industrial mineral and rock geology; and the University's location at the hub of a multi-billion dollar copper-silver ore deposit province demands involvement in base metal exploration and research.

In the Laboratory of **Economic Geology** will be found broad instrument and laboratory support, with special capability in petrologic and mineragraphic techniques. In **Mining and Geological Engineering,** attention is now being given to minerals and

L. G. Wilson

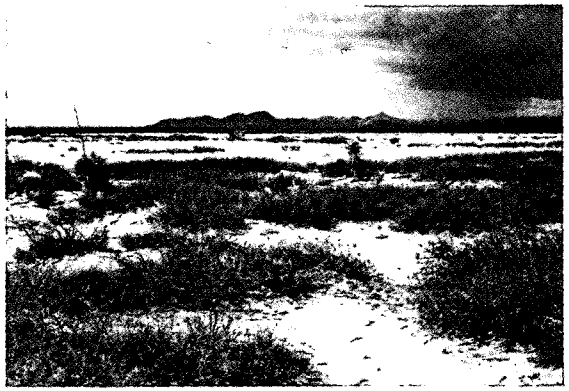
This stabilization lagoon in use by the Pima County (Arizona) Department of Sanitation shows platform, water sampling wells and access well, facilities used for studies on subsurface water movement and quality transformations (including nitrate ion) during deep seepage. Cooperating University departments: ***Civil Engineering*** *and the* ***Water Resources Research Center.***



N. F. Oebker and A.D. Halderman

At the University's Mesa Farm in the Salt River Valley, bell peppers are being cultivated under a drip irrigation system that provides for timer valves, set for a given volume of water, and meters for measuring the amount (foreground), fertilizer injector pump, and half-inch diameter pipe laid along the rows under either alumnized or black-coated paper mulches. While this practice has the prime advantage of water savings, it also requires lower labor costs compared to conventional irrigation systems. Experimentation is still going forward into problems associated with these practices whose solution will help desert farmers everywhere utilize this system beneficially.

View of a summer thunderstorm on the San Simon Valley, southeastern Arizona. Average annual precipitation in this area is about 9.5 inches. The sand dune mesquite (Prosopis) *vegetation community in the foreground includes very little herbaceous vegetation as a consequence of heavy livestock grazing and recurring droughts in the late nineteenth and early twentieth centuries. The grass in the background is a result of brush control methods, species trials, and seeding research by the* ***School of Renewable Natural Resources*** *under a contract with the Bureau of Land Management. The established grass stand is effective in reducing soil erosion from this frail watershed of the San Simon.*

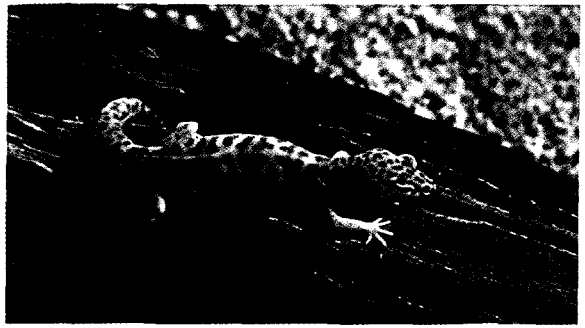


School of Renewable Natural Resources

environmental conservation, where the impact of mining on the environment, and the management of mine wastes and reclamation practices are being assessed.

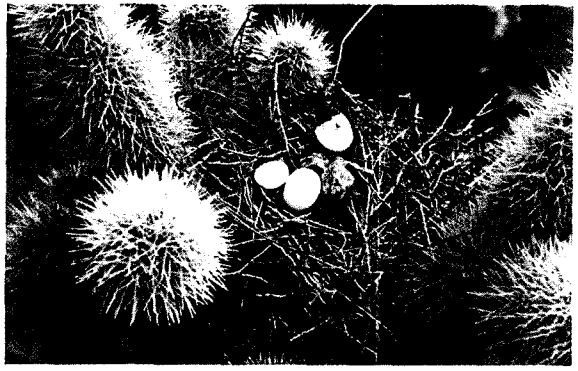
Biological:

The biological resources of the arid Southwest are surprisingly rich and varied, and much of the University's efforts in this field are devoted to a deeper understanding of the area's natural history. Studies in plant geography and zoogeography provide abundant experiences with living laboratories available at such sites as the **Marine Science** Laboratory at Puerto Penasco on the Gulf of California; the **Desert Biology Station** at Superior, Arizona. where arid zone flora and fauna are displayed in a relatively undisturbed 1,200-acre preserve; and **Tumamoc Hill** on the edge of Tucson proper, where a 75-year history of a desert environment little touched by man is one of the southwest's historic landmarks, now under the management of the University.



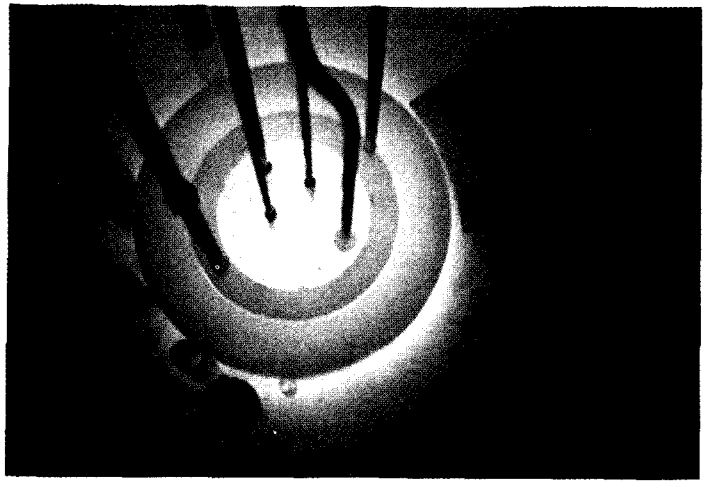
G. Donald Kucera

*This banded gecko (*Coleonyx variegatus*) at ease on the trunk of a fallen ironwood tree (*Olneya tesota*) represents a species of lizard widely distributed throughout the Sonoran and Mojave Deserts. While largely nocturnal in habit, this specimen was photographed very early on a July morning in the Cabeza Prieta, extreme southwestern Arizona.*



R. R. Humphrey

*The combination of barbed spines and densely-armed easily detached joints of this teddybear cactus (*Opuntia Bigelovii*) was no deterrent to the white-winged dove (*Zenaida asiatica*) who built her nest here. This species of* Opuntia *occurs in abundance on warm slopes throughout the Sonoran Desert, including this site west of Caborca, Sonora, Mexico, where the photograph was taken moments after the first egg was hatched.*



Dept. of Nuclear Engineering

TRIGA reactor operating at 100kw of thermal power provides a wide range of research capabilities, covering in addition to nuclear engineering and material uses, projects in agriculture such as feed lot waste problems and analysis of livestock forage digestibility; in earth sciences, dating techniques in geochronology; and in engineering, activation analysis of trace materials.

The Office of Arid Lands Studies

A large diversity of habitats and of game species native to the state provide the framework for a program of game management, with the **School of Renewable Natural Resources** sharing the course and research work with the **Arizona Cooperative Wildlife Research Unit.** The **Arizona Cooperative Fishery Unit** participates in similar activities directed toward learning how to meet the demands for inland sport fishing opportunities in a state where much of the population is outdoor-oriented. Such wildlife and wilderness studies have occupied our research specialists traditionally, but now the emphasis is increased as the University invests its resources in the training of students, including those from foreign arid lands, to seek an understanding in greater depth of the interrelationships of all forms of desert life and the total desert environment.

From its beginnings in 1958 as a loose collaboration of faculty and research associates with common arid lands interests, the OALS has evolved to its present position as a research and information center that coordinates University-wide arid lands programs aimed toward the solution of both local and worldwide problems in the understanding, regeneration, and development of the world's arid lands.

Throughout its development to its present configuration, the **Office of Arid Lands Studies** has held fast to its primary concept, that desert and arid lands studies are interdisciplinary in nature, and that only through the interaction of many subject areas can the total arid environment be understood and dealt with intelligently and factually.

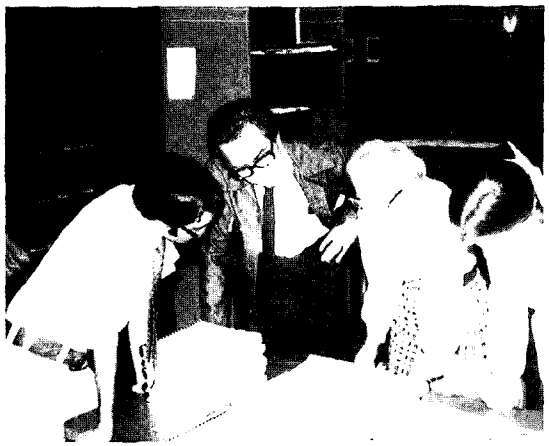
The OALS seeks to identify arid lands research investigations on a broad spectrum of disciplines, and to bring together those research scientists whose interests are correlative. Such integration is being conducted not only locally, but internationally, as relationships are established to provide opportunity for mutual cooperative undertakings. The research activities of the OALS itself are reflected in the design of the many international conferences and seminars it plans and conducts on such diverse topics as economic plants, energy, remote sensing, technology transfer, and desertification. This microcosm of world arid lands dilemmas and the efforts being made for global responses represents in itself the framework of interconnectedness in which arid lands research flourishes best.

In addition to prime funding from the University, support for the OALS has come from such sources as the Rockefeller Foundation, U.S. Army Research Office, National Science Foundation, National Aeronautics and Space Administration, U.S. Department of the Interior, U.S. AID, the U.S.-Israel Bi-National Science Foundation, and many state and local governmental agencies.

On the practical level, the OALS administers the unique Doctor of Philosophy degree in **Arid Lands Resource Sciences** for the Graduate College. This broadly-based interdisciplinary degree introduces a new dimension to opportunities for the unusually gifted mature student who may not fit into the traditional academic degree-granting structure but who has the qualities and experience to make an outstanding contribution to the worldwide problems of the arid lands. He must be able to demonstrate the research skills needed to stand up to the rigorous program required, and to show evidence of competence beyond that expected of the average doctoral candidate.

In addition to furnishing information services to the public and the scientific-government community through custom computer print-outs from both the worldwide coverage available from the Arid Lands Information System (ALIS) and from the Arizona Water Information System (AWIS), the OALS is experimenting in cooperation with the University's **Radio-TV-Film Bureau** with the use of satellite transmission of its arid land information resources through remote terminals.

The OALS issues a series of publications entitled Arid Lands Resource Information Papers, Arid Lands Abstracts, *and several series of newsletters and bulletins. Its University of Arizona Press books include* Deserts of the World, Arid Lands in Perspective, Food, Fiber, and the Arid Lands, *and* Arid-Lands Research Institutions: A World Directory. *Besides such OALS books as these, the University of Arizona Press has published other titles in its arid lands series, including* The Sonoran Desert, Coastal Deserts, *and* Polar Deserts.



OALS staff member goes over a computerized bibliography for visitors to the DocCenter.

Left to right: Dr. Assibi O. Abudu, National Economic Planning Council, Ghana; Wade Sherbrooke, Office of Arid Lands Studies; and Mr. Mike Henry, instructor in agriculture, Baboquivari High School, Papago Indian Reservation, examining a jojoba plant.

International

For over eighty years University applied research has been largely arid lands-oriented to serve the people of a state more than ninety percent arid or semiarid. Within Arizona's boundaries are counterparts of the natural features of all arid lands except such cold continental deserts as the Gobi and such cool coastal areas as the Atacama. No desert area of comparable size contains a greater variety of arid landscapes:

> In some areas of the state, average annual precipitation is less than 3.5 inches (compare As Samaway, Iraq). In others, sheep graze and crops grow where temperatures dip to minus 32 degrees Fahrenheit (compare southern portions of cold Asiatic deserts) . . .
>
> Climatic diversity in Arizona is caused largely by scattered mountains and tabular highlands, conditions similar to those of northern Algeria . . .
>
> Processes and results of weathering, erosion and deposition have been examined at less than 200 feet elevation along the Colorado River, just as on the Nile, while the Colorado Plateau stands at elevations comparable to portions of the plateau of Iran, the central Sahara, and the Kalahari . . .
>
> Since this state's portion of the American southwest has historically and currently a greater variety of human activity than any other desert area, it is a useful one for drawing human-use analogies. The seminomadic sheep grazing of the Navajo, for instance, is much like that of the Kirghiz of Asia and the Berbers of Africa, while flood agriculture has been practiced in Arizona by several Indian tribes, as in the Sahara.

These similarities have sponsored an affinity between the University of Arizona and regions of the Earth with comparable environments. Students from arid lands outside the United States constitute fifty-two percent of the total University of Arizona foreign student body, with Saudi Arabia, Libya, Mexico, Israel, Jordan, Morocco, and Iran among those represented. Many such students are here for graduate studies in fields chosen to contribute a greater understanding of their homeland needs, and solutions to their own arid lands problems. Many former students have gone on to positions of responsibility in government, education, and technology. Their ties remain strong with Arizona, through contacts continued by mail, by visits in both directions, and by durable relationships based on mutual arid lands interests.

Institutional programs of international scope have sent faculty and research personnel on arid lands assignments in northeastern Brazil, Turkey, West Africa, Sudan, Pakistan, Peru, Israel, Australia, India, the Sahara, Argentina, and elsewhere. The experience of the University over a period of more than eighty years in research on arid soils, irrigation, climate, hydrology, native and introduced vegetation, and other aspects of this environment has been translated throughout the arid world into projects of incalculable benefits.

As neighbors, our history of cooperative programs with the states of northern Mexico and those related to the Gulf of California is a long and close one, the most

Gaud-I-Zirreh, Afghanistan

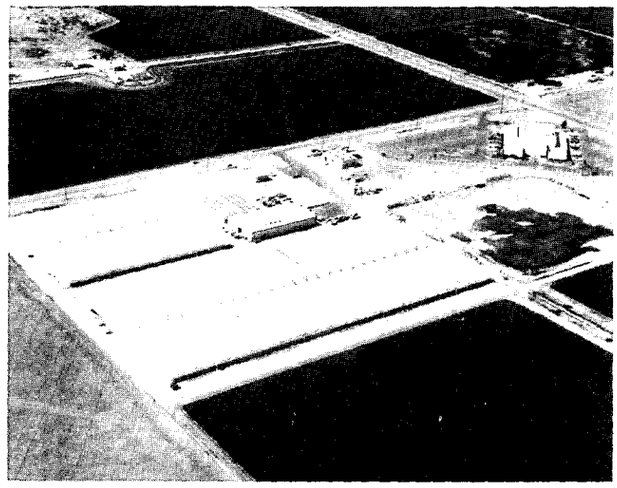
spectacular being the Puerto Penasco experimental facility that began with a desalting project and is now devoted to production of marine shrimp in controlled environment structures. Similar projects growing out of the original desalting program there have been undertaken under the direction of the University's **Environmental Research Laboratory** in Abu Dhabi and Iran, where large-scale power/water/food plants are in full-scale operation; and in Fort Yuma, California, where a comparable facility is in operation by the Quechan Indian tribe.

International research on economic wild plants is another area where the University of Arizona's leadership is demonstrating its capacity to identify and explore arid lands potentials. Jojoba *(Simmondsia chinensis)*, native to the Sonoran Desert, is presently the most visible, now being experimentally cultivated in Israel, Iran, Iraq, and Australia. Its spread under these conditions will eventually be assured, with the several benefits that can accrue from its products and use. Guayule *(Parthenium argentatum)* and the common buffalogourd *(Cucurbita foetidissima)* are other native plants with economic possibilities now being re-examined for research investigations through international collaboration.

Beyond these formal and informal alliances with governments and institutions throughout the arid world, the University of Arizona is dedicating its experience and competence in a number of ways. Its membership in the Consortium for International Development (CID) assures that it has a role to play in determining the needs of less-developed countries in arid and sub-humid areas, and in contributing to ways of meeting those needs.

U.S. AID projects designed to develop training in natural resources management will have great impact in arid regions other than the southwest U.S., where pilot programs in microcosm can be extrapolated to the macrocosm of the world's arid lands. Such renewable natural resources as forests and their effects on watersheds, game management, recreation, and hydrology can be cited, where substantial academic effort is devoted to creating the kind of experiential background necessary to understand and direct programs of conservation and development.

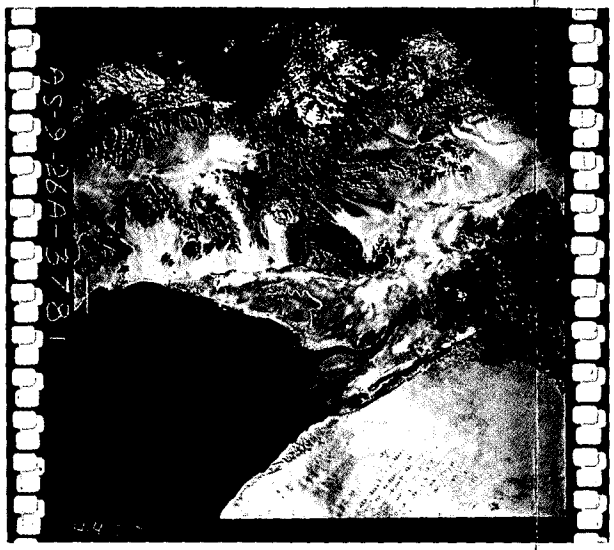
The influence of such unique research capabilities as those present in the **Environmental Research Laboratory,** the **Laboratory of Tree-Ring Research** and its programs in dendrochronology, and the work of the Department of **Geosciences** in the fields of palynology and isotope geochemistry, for instance, is far-reaching. While research done in the arid environs of the University of Arizona provides the state of Arizona with an understanding of ways of responding to such demands as are made on us in the fields of groundwater, energy, the environment, such research can be extended in the service of comparable needs elsewhere, as indeed it has been traditionally.



Comparable to installations in Abu Dhabi and the Arabian Gulf is this large-scale power/water/food plant in full-scale operation by the Quechan Indian Tribe at Fort Yuma, Arizona. Here five acres of tomatoes grown for the commercial market are being cultivated in the greenhouses shown in the photograph. The facility is operated and administered by the Tribe, providing employment and income. Well water is brackish but used as it comes for the cooling aspects of the operation. A water treatment facility provides better quality water for irrigation.

The Catalina Mountains, a gneissic massif uplifted 25 to 30 million years ago, form the northern boundary of the Tucson basin and rise to an elevation of 2,770 meters. Vegetation in the foreground is dominated by the Saguaro cactus (Carnegiea gigantea), *a plant unique characteristic of the Sonoran Desert.*

Technology



NASA

Apollo photograph of Colorado River Delta from an altitude of 126 miles.

The Desert from Space:

The gaps in our knowledge of various aspects of the physical features of the world's arid lands are enormous, in part because of the inaccessibility of many areas, in part because of the inhospitable nature of deserts. Now we have an opportunity to conduct detailed natural resource and land-use inventories using aircraft and spacecraft imagery. The remote sensing techniques developed by NASA and the U.S. Geological Survey are being employed at the University of Arizona to give us the synoptic view that we urgently need to establish our development priorities.

The worldwide search for scarce resources is being enhanced by this technology, as we use U-2 and satellite data to monitor hydrology and water, marine, soil and vegetation, minerals and fossil fuel resources, and land use and land use changes. In each of these areas, research data are being improved and expedited as we learn to correlate information from space with ground surveys. For many reasons, this technology is most admirably suited to arid lands, and its employment here on an ever-increasing scale is a significant factor in our present and future investigations. Remote sensing technology is used throughout the University, with laboratories in the **Office of Arid Land Studies** (Applied Remote Sensing Program), **Optical Sciences, Biological Sciences, Geosciences, Civil Engineering, Mines,** and **Agriculture.** The campus-wide **Remote Sensing Committee** coordinates academic endeavor and serves as a focal point for the many and varied remote sensing activities.

Computer Services:

Aside from courses offered in computer science, the technical services of the University's **Computer Center** are employed in a number of ways related to the arid lands research program. The Arid Lands Information System (ALIS) of the **Office of Arid Lands** is a completely computerized system used in the preparation of its specialized bibliographies and in custom searches on arid lands inquiries. As a sub-system of ALIS, coverage of watershed management and related subjects is provided by the **School of Renewable Natural Resources.** Similar services are furnished by the Arizona Water Information System (AWIS), also a function of the Office of Arid Lands Studies in cooperation with the **Water Resources Research Center** and the Arizona State Water Commission.

The new DEC-10, in addition to the CDC 6400 and smaller analog and digital computers in use across the campus, is giving the University computational capacity through individual terminals that will greatly accelerate the use of data acquired in several ways for the vital arid lands studies going forward in such areas as hydrology, land use planning, natural resource inventories, and particularly in modeling and simulation of desert biome sites.

Arid Lands Research in Academic Departments

The following departments and divisions of the University of Arizona offer courses and conduct research closely related to arid lands studies in all subject fields represented. For further information in any of these specific areas, please write to the Head of the individual unit, c/o University of Arizona, Tucson, Arizona 85721, USA.

College of Agriculture
- Agricultural Economics
- Animal Sciences
- Entomology
- Nutrition and Food Science
- Renewable Natural Resources
- Soils, Water, and Engineering

College of Architecture

College of Business and Public Administration
- Geography, Regional Development, and Urban Planning

College of Earth Sciences
- Geosciences
- Hydrology and Water Resources

College of Engineering
- Aerospace and Mechanical Engineering
- Civil Engineering and Engineering Mechanics
- Electrical Engineering
- Nuclear Engineering
- Systems and Industrial Engineering

College of Liberal Arts
- Anthropology
- Atmospheric Sciences
- Biological Sciences
- Oriental Studies
- Political Science
- Psychology

College of Mines
- Mining and Geological Engineering

Computer Center

Coordinator of Interdisciplinary Programs

Coordinator of International Programs

Environmental Research Laboratory

Office of Arid Lands Studies

Special Research and Service Divisions
- Arizona Agricultural Experiment Station
- Arizona Bureau of Mines
- Arizona Cooperative Fishery Unit
- Arizona Cooperative Wildlife Research Unit
- Arizona State Museum
- Bureau of Ethnic Research
- Engineering Experimental Station
- Herbarium
- Institute of Atmospheric Physics
- Institute of Government Research
- Laboratory of Tree-Ring Research
- Optical Sciences Center
- Radio-TV-Film Bureau

Water Resources Research Center

ARID LANDS RESEARCH AT THE UNIVERSITY OF ARIZONA

Jojoba (Simmondsia chinensis), *native to the Sonoran Desert of southern Arizona, southeastern California, and northwestern Mexico including Baja California, has several potential uses now being explored by the* ***Office of Arid Land Studies*** *in cooperation with researchers in California, Mexico, and Israel. The development of an Indian jojoba industry based on successful experimentation with a number of these is being undertaken at the University in conjunction with several Arizona Indian tribes, looking toward establishment of large plantations to support industrial uses such as candles, waxes, lubricants, high-protein animal feed supplements, and even as ornamentals.*

E. F. Haase

Developing Countries . . . Environment . . . Arid Lands . . . Natural Resources

Southwest Asia . . . Wind Power . . . Remote Sensing . . . Africa . . . Watersheds . . . United Nations . . . AID

ARID LANDS NEWSLETTER

No. 4
October 1976

UNIVERSITY OF ARIZONA
Tucson, Arizona 85721, USA

Mapping . . . Sahel . . . Archaeology . . . Irrigation . . . Information . . . Transhumance . . . Energy

Geothermal . . . ALIS . . . Desertification . . . Economic Plants . . . Research

ARID LANDS NEWSLETTER*

No. 4, October 1976

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Editor: Patricia Paylore, Assistant Director (International), Office of Arid Lands Studies, University of Arizona, Tucson, Arizona 85721, USA.

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QUERY TO READERS:

If you readers out there, whoever you are, wherever you are, whatever your concerns are, want to use *Arid Lands Newsletter* as a forum to speak out through letters to the Editor, I should like to add a page or two in each issue for this kind of exchange.

Please keep them brief and to the point, and do not feel hurt if I cut or change or don't use at all. That's what mean editors are for.

Next issue will be out by January 1, 1977, so take pen in hand and let me know what you are thinking about arid lands problems, or what you would like to see covered in future issues, or what you don't like about what has already appeared.

– PP

MANAGEMENT OF BRACKISH WATERS IN ARID LAND AGRICULTURE: Modern Experiences with Ancient Problems

by

Marvin Twersky*

I. INTRODUCTION

In those arid areas worldwide which conceal in their depths an abundance of water containing variable quantities of soluble salts, irrigation agriculture presents us with a modern challenge to utilize such water resources nevertheless for intensifying crop production to feed the inhabitants of those regions. Since there is as yet no economical large-scale way to eliminate salts from brackish water, we need to concentrate on ways of living with saline irrigation water whose varying salt composition can contribute to improper water management and to increased soil salinity. To achieve this, we need to define the vulnerability of soils and crops to the dangers of various water qualities, and to use this knowledge to correct irrigation technology accordingly.

The objective of this paper is to point to modern opportunities in brackish water irrigation technology that make it possible to achieve economical production of food-fiber crops. In Israel, where 200 million cubic meters of brackish waters are available yearly for agricultural use, new techniques based on the national experience have contributed to successful cultivation of those desert regions employing brackish water irrigation (Fig. 1).

Fig. 1. Field of cotton seedlings irrigated with brackish water.

II. WATER QUALITY AND SOIL SALINITY CRITERIA

A. Criteria of Water Quality

The term "quality of irrigation water" implies a specific rating of the potential hazards water has for crops and soils (24, 34, 48). Waters vary from one source to another in one or all of the following: 1) total dissolved solids (TDS); 2) cationic and anionic composition (Na^+, Cl^-, sodium adsorption ratio, residual sodium carbonate, permeability index); and 3) phytotoxic impairments (B^- limits, NO_3^- concentrations, pathogens and disease organisms). Water quality can be expressed as total salt concentration in ppm, mg/1, pr ppm Cl^-, especially where Cl^- sensitive crops are involved (e.g., citrus) (22, 34). The total dissolved salts (TDS) is most easily measured by electrical conductivity of water (EC_W) and is expressed as mmhos per cm at a temperature of 25°C (mmho/cm).

Specifically, waters having EC_W ranging from 2-8 mmho/cm (1000-10,000 ppm) are considered brackish (i.e., slightly to moderately saline) (11, 37). Waters having greater salt concentrations are classified as saline. Brackish waters of up to 5000 ppm are of the most potential interest for irrigation agriculture.

In practice, no singular set of criteria exists for brackish/saline waters (21, 30, 34, 48). Available water resources for irrigation programs must be assessed in the context of the conditions under which they are to be used. Any classification system based on the composition of water alone can serve only as a general guide in water management programs because of the interactive effects of soil, plant, and climatic conditions in each locality.

B. Salinity Criteria in Irrigation

Two factors are important for assessing the suitability of brackish water for irrigation: 1) the amount of salt accumulated with each irrigation in the soil profile, and 2) the degree of response of a specific crop to the level of soil salinity in the root zone.

Salts accumulate in the soil profile due to evapotranspiration, which is controlled by climatic demand and the physiochemical properties of the soil (1, 7, 28, 31, 44, 48). The movement of water and salt in the soil profile is less restricted in light (sandy) to medium-textured (loamy sandy) soils due to their high infiltration capacity.

The salt resistance of crops largely determines the suitability of brackish water for irrigation. The salinity damage

*Dr. Twersky, a University of Illinois Ph.D. (agronomy, 1964), is Senior Scientist, Research and Development Authority, Ben-Gurion University of the Negev, Beer-Sheva, Israel, where he specializes in saline water-soil-plant problems.

to a crop, however, is a combination of plant growth stage, rate of soil salinization, and duration of exposure to soil profile salinity in the irrigation interval. Due to the heterogeneity of soil in space and time within the soil profile, it is the weighted mean soil salinity that determines the performance of an individual crop. Weighting of soil salinity is done on the basis of water uptake by plant roots (46).

Our experience suggests that the most singular soil salinity problem occurs during the first stages of germination, emergence, and plant establishment. The buildup of salts at the soil surface due to evaporation delays germination, and causes poor emergence and spotty seedling establishment.

Sugar beets serve as a classic example, being very sensitive at the germination-establishment stage, though highly salt resistant at maturity (4, 29). Peanuts, on the other hand, are nonsensitive at initial stages of germination, but are highly salt-sensitive to brackish water as mature plants (35, unpublished results).

It is possible to increase seed planting quantity in order to attain a higher density and more uniform plant population (Table 1), or substitute fresh water irrigation (if available) at these salt sensitive stages of plant growth.

Table 1. Effect of Planting Rates on Seedling Establishment of Crops Sprinkle-Irrigated with Fresh or Brackish Water (27)

PLANTING RATE	ONIONS		CARROTS		ALFALFA	
	EC_W mmho cm^{-1}					
%	1.0	4.0	1.0	4.0	1.0	4.0
	number of seedlings m^{-1}					
100*	17*	14	83*	56	29*	24
130	23	19	126	72	39	34
200	33	28	198	120	51	36

*Acceptable field practice in Israel.

Although there is general agreement as to the relative salt resistance of various crops (4, 22, 27, 44), information on the influence of salinity on growth is scattered and difficult to evaluate (9). Salt tolerance tests should be carried out within an ecologically discrete area in order to have the greatest validity. The USDA Salinity Laboratory, Riverside, California, has prepared a reevaluation of salt tolerance literature covering the last 80 years.

C. Leaching Control Criteria

When more water is applied than the plant requires, the extra water moves the salts past the root zone. This is known as leaching (22, 25, 28, 31, 33, 44) and is more efficient under unsaturated flow conditions (26). Proper leaching and drainage management prevents salts from building up in the root zones of plants.

The effectiveness of leaching is determined by irrigation frequency, amount of water in each application, and specific irrigation methods. Surface flooding, sprinkler, and trickle/drip irrigation have different effects on salt accumulation and soil salinity distribution. Control of soil salinity by leaching, therefore, is a function of the irrigation management system (7, 32, 46).

III. IRRIGATION SYSTEMS USED WITH BRACKISH WATER

A. Surface Methods

Surface flooding methods are used in the traditional irrigation systems existent in 95 percent of the irrigated lands of arid regions (12, 13). These techniques are the easiest to operate and have lower initial capital costs than sprinkler or trickle/drip methods, even though they have certain inherent weaknesses for utilization of brackish water.

(1) Flooding

Surface flooding requires land leveling. This destruction of the physical structure of the soil surface decreases leaching efficiency.

Distribution of the water is uneven, requiring more water per unit area, with constant vigilance of the surface coverage. Irrigation efficiencies are low, only 55-70 percent (37). In sandy soils, surface irrigation is very inefficient.

More water is required per irrigation for leaching. On the other hand, a surplus of water may cause waterlogging and increased soil salinity.

(2) Furrow Irrigation

Furrows are used for the irrigation of row crops on gently sloping lands. However, there is more soil erosion with this method.

The salt content of the soil will vary from place to place with brackish water furrow irrigation, with the greatest salt concentration being in the center of the bed near the surface. Accumulation of salts on the surface affects germination (16, 32). For highly brackish waters (>5000 ppm) the furrow method is less satisfactory.

B. Sprinkler Irrigation

There is a clear superiority of sprinkler irrigation over surface irrigation (12, 13, 37, 45, 46) in brackish water management.

Irrigation efficiencies are higher (60-80 percent) than with surface irrigation methods. Watering can be controlled in time and intensity simply by choosing the right combination of sprinklers, nozzle size, line pressure, and spacing of sprinklers (Fig. 2).

Sprinkler irrigation is comparatively more efficient for leaching salts in the soil (16, 46). By regulating sprinkling at a rate below the maximum infiltration capacity of the soil, the water content of the soil profile is controlled. Because of slower profile wetting, the zone of leached salts is extended deeper into the soil profile than with surface irrigation. Intermittent leaching has been found to be more efficient in salt removal per unit water applied (26).

Fig. 2. Demonstration of sprinkler equipment.

The many existent types of sprinkler systems [portable, semi-permanent, and permanent (solid-set) installations] can be adapted to most crops. In Israel, a variety of crops have been grown successfully using brackish water (Table 2, Figs. 1-2).

As with all irrigation systems, sprinkler irrigation also has its disadvantages, but to a great extent, these can be overcome by proper management (19, 47).

The small droplets of sprinkler spray are more subject to evaporation and wind drift, the latter causing a distortion of water application pattern (19). The resultant decrease in leaching efficiency can be particularly harmful when using brackish water. This can be partially overcome by irrigating at night (33).

Large droplets can cause damage to salt-sensitive emerging plants and increase crusting of the soil surface. The impact of energy of the drops tends to destroy the aggregates at the soil surface causing particle dislodgement and soil splash (Fig. 3).

Table 2. Yields of Crops Sprinkle-Irrigated with Either Fresh or Brackish Water in the Negev Area (8, 13, 27, 41, 42, 43)

CROP	EC_W mmho cm^{-1}		REMARKS
	1.0	4.0	
	—yield, tons ha^{-1} —		
Cotton	4.25	5.40	seed cotton
	4.74	5.20[d]	(2 locations)
Wheat	6.70	6.70	grain
Sorghum	10.0	8.40	grain
Sugar beets	80	60	taproot
Forages			
Bermudagrass	–	33	dry weight
Rhodes grass	21.0[a]	33	dry weight
Peas (canning)	18.5	17.2	green pods
Onions	34	26	bulb
Sweet corn	17[c]	6.3[e]	
Muskmelon	24	–	
Tomatoes			
–	78.0[b]	31.0[e]	table
VF145 F5	72.0	38.8	processing varieties
Meacheast 22	78.5	57.1	processing varieties
VF 198	86.5	49.1	processing varieties
Napoli	108	73.5	processing varieties

a. average for State of Israel
b. water EC_W = 1.2
c. water EC_W = 0.4
d. water EC_W = 4.6
e. water EC_W = 3.6

The NaCl of brackish waters intensifies this effect. The plant establishment problems of salt tolerant crops (45) may also be due to this effect. Large droplet size can be controlled by decreasing nozzle diameter or increasing water pressure (19).

Overhead sprinkler irrigation with brackish water must be avoided during daytime windy and dry hours. The process of mineral uptake of leaves is intensified when brackish water is

Fig. 3. Soil splash damage of onion seedlings. *Right:* Heavy soil splash showing leaf tip damage before brushing. *Left:* After brushing off soil particles.

applied by sprinkling (2, 40). Accumulation of salts, especially chlorides, on the leaves causes leaf burn and defoliation. By irrigating at night, the dangers of foliar salt adsorption are decreased (32).

C. Trickle/Drip Irrigation

Development of trickle/drip irrigation methods has introduced a new and exciting innovation for management of brackish water (2, 5, 6, 8, 13, 15, 17, 23). The common use of tricklers has grown rapidly in recent years with 29,000 ha being irrigated in the U.S. and another 29,000 ha in other areas of the world. This amount will more than double in five years. Trickle/drip irrigation has been found to be particularly suitable where land is difficult to level and where sandy soils predominate. In Israel, a variety of crops which have been considered too sensitive to brackish water irrigation have been grown efficiently and economically with tricklers (Table 3).

Table 3. Yields of Crops Trickle/Drip-Irrigated with Brackish Water (EC_W = 4) in the Negev (8, 13, 27)

CROPS	YIELDS
	tons ha^{-1}
Tomatoes	80-113
Muskmelons	23-48
Watermelons	23-62
Cucumbers	25-42
Sweet Corn	12[a]
Onions	50
Eggplant	35

a. Water EC_W = 4.5

Trickle/drip irrigation gives greater water control. The system consists of plastic pipes (hoses) placed on the surface amongst the plants (the preferred method), or under the soil. The water is delivered in the pipes under low pressure where the water enters drippers (emitters), which reduces the line water pressure and is discharged as drops at a controlled rate (Fig. 4).

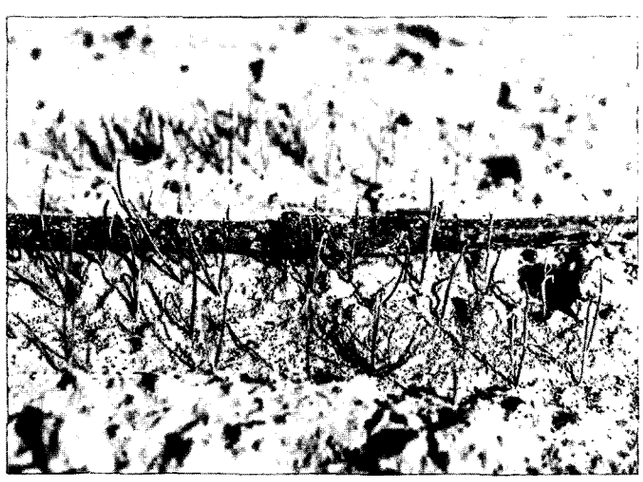

Fig. 4. Trickle (dripper) emitter on onion seedlings.

Success of the surface approach is due to the formation of a low salt zone in the vicinity of the trickler where most of the roots tend to cluster (5, 33). The dripper is placed directly on the soil surface so that the area across which infiltration takes place is small compared with the total soil surface. Salts from the irrigation water are concentrated in a shallow surface layer (from evaporation) and in a deep layer with a leached zone between them. The result can be described as three-dimensional water flow as opposed to the one-dimensional flow of flood and sprinkler and two-dimensional of furrow irrigation. In drip irrigation, delivery of the leaching water to the actual root zone is therefore more efficient than in either surface flooding or sprinkler irrigation. Furthermore, soil moisture in the immediate root zone is continuously high, maintaining a low salt concentration level.

Like the other irrigation methods, trickle/drip systems also have inherent technical weaknesses which limit their usefulness (6, 13, 15, 23). Experience has shown that these methods require more careful management than surface flooding or sprinkler irrigation. More skill is needed in design, installation and operation. Major problems are encountered with plugged drippers (emitters), rodent and bird damage, and fluctuating water pressure. There can be a buildup of accumulated salts in the regions between tricklers, where there is a predominantly upward water flow near the soil surface. This salt accumulation affects germination and establishment of plants in the regions between tricklers (16).

Even though trickle/drip irrigation methods have contributed to the success of growing salt-sensitive crops with brackish water, development of these methods lags behind that of others discussed (23). However, systems are being developed that should be more efficient and economical for a broadening variety of crops.

IV. IMPROVING AND OPTIMIZING SOIL-PLANT-FERTILIZER AGROTECHNICS

New management concepts have become available for the control of soil water and salinity (6, 7, 18, 23, 25, 26, 28, 33, 46).

A. Salinity Measurement Techniques

Practical methods are being developed that can provide immediate on-the-spot soil salinity information. One method estimates *in situ* soil salinity (EC_e) with a 4-electrode conductivity probe (14). The information can be used by the farmer to plan a proper irrigation-leaching schedule which will minimize development of adverse root zone salinity levels.

Salinity sensors and tensiometers can be utilized for continuous monitoring of soil water and soil salinity (25). This could provide *in situ* feedback information for automatic control of soil water and salinity within the root zone. However, salinity sensors and tensiometers are at present subject to control levels and appropriate depth placement restraints.

B. High Frequency Irrigation (HFI)

We can now apply water at a low enough flow rate so that the infiltration rate is controlled by the irrigation system rather than by the soil. By using frequent light applications of water, the irrigator no longer depends on storage of soil water to supply water demand of the crop between irrigations.

High frequency irrigation (HFI) optimizes the water and salt balance in the root zone while drastically reducing water use (6, 7, 28, 46). This technique maintains high water content in the root zone and at the same time prevents excessive drainage. More frequent irrigations raise the time average of the soil water content even with leaching, thus assuring the average actual salt concentration and water suction to be lower. HFI salinity control will in turn modify crop response to the salt concentration of the irrigation water.

Systems meeting requirements for HFI range from solid-set or travelling sprinkler to trickler/drip systems (28, 46). A hazard of HFI sprinkling with saline water is that it can cause damage to leaf tissue and reduce yields (1). This of course is not a problem in trickle/drip irrigation.

C. Automatic Irrigation Control Systems

Changes in salinity control management require more precise control of large irrigation systems. The application of automatics and electronics to irrigation is essential if resources of brackish water are to be optimally exploited (8, 13, 46).

Since most brackish irrigation should be done at night, water losses have to be prevented by automatic detection of line leakage and breakage.

Automatic water meters for quantity and flow control can be used to regulate brackish water delivery by amount rather than time (Fig. 5). This is particularly important in HFI. By utilizing several valves, it is possible to operate lines sequentially. Each line receives the amount of water necessary for leaching, which is calculated on the basis of updated records.

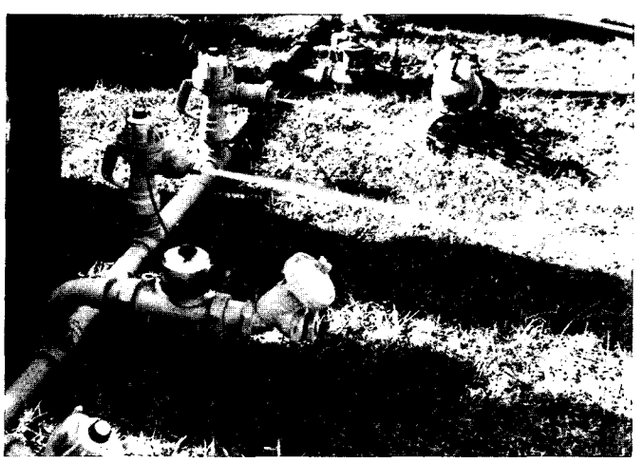

Fig. 5. Automatic water meters for quantity and flow control.

If at least a small amount of fresh water is available, a network of lines can be designed to deliver alternately fresh and brackish water for the purpose of briefly washing the plant canopy. This would decrease the danger of foliar absorption of salts already mentioned in sprinkler irrigation.

The salinity sensors and tensiometers discussed under measurement techniques can be incorporated in automatic systems.

D. Optimizing Chemical Fertilization

Agrotechnics for leaching accumulated salts must be integrated with fertilizer programs (44). The leaching required when using moderately saline water also removes nutrients from the soil especially nitrates (10, 16). This requires higher fertilizer inputs with modern irrigation systems. Tomatoes fertilized daily with nitrogen have larger and stronger seedlings (Table 4, Fig. 6). In the Arava of Israel, 2 kg ha^{-1} of nitrogen fertilizer is applied daily to tomatoes irrigated with brackish water. The results vindicated the high fertilizer input in trickle/drip irrigation systems.

Table 4. Effect of Nitrogen Fertilization on Tomato Seedlings Trickle/Drip Irrigated with Fresh or Brackish Water in a Sandy Loessial Soil (10)

DAYS AFTER PLANTING	CONTROL		KNO_3		NH_4NO_3	
	EC_W, mmho cm^{-1}					
	1.0	4.0	1.0	4.0	1.0	4.0
	dry weight, mg $plant^{-1}$					
17	11	9	29	29	57	34
26	78	48	164	135	307	208
35	462	250	808	628	1,515	952

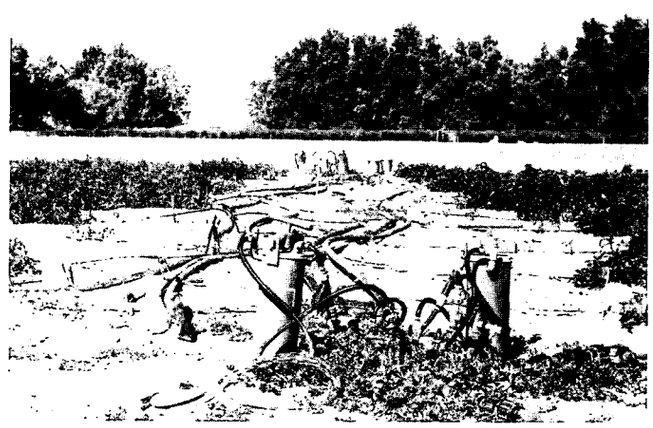

Fig. 6. Applying nitrogen fertilizer via trickle irrigation system to tomatoes.

Fertilizer programs can be formulated to 1) alleviate nutrient imbalances, 2) counterbalance specific salt toxicities, or 3) increase the total salt tolerance level of particular plant species (44).

Automated irrigation systems create new opportunities and strategies for placement and timely application of nutrients in combination with brackish water leaching management.

E. Selection and Genetic Potential

Selection of crop varieties should be made in accordance with local conditions. For example, it is known that vegetables generally do not have high salt resistance, but in recent experiments in the Negev of Israel, out of seven varieties of processing tomatoes, 2-3 varieties show a commercial potential with irrigation water of $EC_W = 4$, although there was a reduction in yield (Table 2). In a greenhouse experiment with grain sorghum, forty-eight cultivars were found to differ widely in their ability to germinate and grow as seedlings under high-salt conditions (36). A Mexican wheat variety has been found that has 2-4 times greater salt resistance than three other wheat varieties (38). Efforts must be increased to look for those species and genotypes adapted to higher levels of salinity.

Plant breeders have known for some time that certain crops are more salt tolerant than others. However, virtually no attempts have been made to exploit the genetic potential of desirable plant components. Brackish water may increase desirable plant components and improve the market and storage quality of vegetable crops (20).

V. FIELD INDICATORS FOR IRRIGATION NEEDS

Growers must be on the alert for the macrophysiological responses of plants to water-salinity stresses (3). A few indicators are: changes in leaf color, where leaves of stressed plants become darker; changes in plant movement or elongation, where leaves curl or change their angle of orientation; and leaf temperature, where stressed plants feel warmer to the touch.

Commercial instrumentation to monitor macrophysiological stress changes in plants under field conditions is still far from practical development.

VI. CONCLUSION

Modern research has not only contributed to an understanding of the dangers and shortcomings of brackish water irrigation, but has also provided the farmer with modern technological means for overcoming them. Looking ahead, research developments indicate that we are on the verge of significant management improvements leading to a viable arid lands agriculture based on brackish water irrigation.

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AAAS COMMITTEE ON ARID LANDS
Directory of North American Arid Lands Scientists

The AAAS Committee on Arid Lands is preparing a directory of North American (including Mexican) scientists active in arid lands research, including geology and geography, biological sciences, anthropology, social and economic sciences, engineering, medical sciences, agriculture, atmospheric and hydrospheric sciences, and other related sciences. The directory will be on computer tape at the University of Arizona's Office of Arid Lands Studies, with continuous updating. If you have not already seen the announcement in a recent issue of *Science,* send your entry to either Dr. Gordon L. Bender, Department of Zoology, Arizona State University, Tempe, Arizona 85281, or to Patricia Paylore, Office of Arid Lands Studies, University of Arizona, 845 North Park Avenue, Tucson, Arizona 85719. We need to know your title, professional address, specific arid lands interests, both geographical and subject. A computer-produced publication is anticipated in time for the United Nations Environment Programme's Desertification Conference in the late summer of 1977.

INFORMATION WORKSHOP IN GHANA

by

Mary Michael*

Mary Michael
— *Julie Garrettson (1976)*

At the request of Ghana's Council for Scientific and Industrial Research (CSIR), the University of Arizona sent an information team to Accra for a two-week workshop in late February 1976, on goals of information management, document acquisition and processing, and information retrieval and dissemination. Techniques presented were those used by the University of Arizona-based Arid Lands Information System (ALIS) and its sub-system (WAMIS), with emphasis on arid lands information, including the computerized documentation comprising the Tucson-stored data base. Other members of the team were Nancy Ferguson, Office of Arid Lands Studies Research Associate, and Linda White, Information Systems Specialist, Center for Quantitative Study.

The workshop was one of a series of activities defined by the linkage between the University of Arizona and the CSIR under the auspices of the University's Natural Resources 211(d) Program. The primary objective of the workshop was to present information management techniques to facilitate identification, storage and retrieval of scientific literature pertinent to land and resource management in the semi-arid savannah area in the Upper Region of Ghana. Expanding on this objective, course work was designed so that it would be of value to all information personnel interested in methods for the operation and maintenance of a topically specific literature collection. The broad scope of interests reflected by attendees of the workshop included not only library management of natural resources information, but a variety of disciplines in both the physical and social sciences as well.

The text used for the workshop, *A Handbook for Implementation and Maintenance of a Manually Operated Information Storage and Retrieval System,* was prepared by the University of Arizona workshop team specifically for use at this workshop, and is based on the program developed by ALIS/WAMIS for the identification, acquisition, processing, and use of its respective users. The distinction between bibliographical information prepared for storage, with or without abstracts, and the actual handling of documentation for use in the library sense, was part of the instruction.

The fifty workshop attendees included representatives from several of the CSIR Branch Institutes throughout Ghana, students from undergraduate and graduate programs from the University of Ghana Department of Library and Archival Studies, as well as from other Departments of the University; the Ghana Library Board, the Ghana National Museum, the Atomic Energy Commission, the National Development Bank, the Ghana News Agency, the Department of Civil Aviation, and the Association of African Universities. In addition to presenting basic techniques for management, storage and retrieval of information in the special collection, the workshop brought together special librarians from throughout the country and provided an opportunity to share common goals, problems and solutions.

Following the workshop, two of the team members, Ferguson and Michael, made various contacts with existing information systems in Upper Volta, particularly the Comité Inter-Africain d'Etudes Hydrauliques, Ouagadougou; and in Senegal, with the Organisation pour la Mise en Valeur du Fleuve Senegal, Saint Louis.

*Coordinator of Information Systems, Office of Arid Lands Studies, University of Arizona, Tucson, and Team Leader, Ghana Information Workshop 1976.

Editorial

VIVA LA CUCARACHA!

> To be an animal is to be capable of ingenuity and of joy; of achieving beauty and of demonstrating affection. These are surely not small things, though there is danger that we are forgetting how far from small they are. They are godlike attributes whether or not there is anything else godlike in the universe. To be alive at all, even if only as an amoeba is alive, is to be endowed with characteristics possibly unique and certainly exceptional throughout that vast expanse of space which extends for billions of light years beyond us, farther than telescopes–and much farther than thought–can reach.
>
> Joseph Wood Krutch
> *The Great Chain of Life*
> Houghton Mifflin Co., Boston, ©1957

Historically, man has been ambivalent in his relationships with animals. He has worshipped them, feared them, domesticated them, used and abused them, and now he is in a fair way to exterminating them.

It is somewhat of a tangled web in which desert-dwelling man has entrapped himself, needing animals as those in more temperate environments may not, to survive, as a source of food, to pull his plow, to turn his water wheel, to transport him and his household from place to place as he follows the seasons. With none of these needs do we find a conflict between our role as sentient beings and the uses we make of other sentient creatures. We justify the necessity to slaughter, shoot, club, harpoon, and in all other ways our imagination can devise to kill, because as human beings, we believe we need to eat meat to survive, millions of vegetarians – willing or unwilling – notwithstanding. We see nothing wrong, wicked, evil, or immoral in raising animals to satisfy this hunger. We do this deliberately, expertly, scientifically, whether we live in Arizona or in Kenya.

Animals alive are the index of many men's status in desert societies, or elsewhere for that matter. We equate a nomad's wealth with the number of camels he owns. [What manifestations of this status will be substituted when he is sedentarized?] We build our drought relief programs around the need to replace the desert pastoralist's decimated herd. [Do we help him understand the limitations of the drought-ravaged rangeland, when it is rehabilitated, so that its carrying capacity will be in balance with his animal assets?]

Well, let us not concern ourselves with these nagging problems. Others are worrying about such matters, great international organizations are assembling and preparing position papers to deal with these issues, and generous single governments are fielding expert teams to advise and assist.

So let us think about those other animals, the wildlife supposedly under no man's control. Well, who needs them? Take the kids to the zoo and let them see there the coyote, the Gila monster, the buffalo, the ferret – sorry about the carrier pigeon; or the oryx and the addax and the dama gazelle, far from the desert homeland in the Sudan where they are no longer to be seen in the wild. Who cares? Certainly not the greedy poacher who defies with impunity the feeble laws that do exist some places on paper. Certainly not the evil owner of that wretched U.S. roadside display of animals confined under unbelievable conditions of filth, hunger, thirst, and abuse. Certainly not those Texans celebrating their rattlesnake hunts. Certainly not the western sheepman who cries piteously when a coyote kills a lamb but who cheerfully sends thousands of lambs, if he has had a good year, to the slaughterhouse.

Who cares? Jeremy Swift cares, when he writes: "... It seems that the addax, a beautiful animal whose presence extends the boundaries of the habitable world into the heart of the world's harshest desert, is too exceptional an animal to be allowed to live, even in the deserted dunes for which it alone has been prepared by thousands of years of evolutionary hardship." (*The Sahara,* Time-Life International, ©1975, p. 108.)

And we'll tell you who else cares: the mighty hunters of the world who kill pour le sport, killing for killing's sake, those rich potentates who do their hunting from the air, like gods, from helicopters and low-flying aircraft, guns blazing as they race the impalas across the desert landscape. Is it possible that such human beings – and I use the word human advisedly – can indulge in the exquisitely cruel and senseless ways that he now commands as his authority over the world's diminishing wildlife, and not in the indulgence thereof be diminished himself? We think not.

And can governments which continue to issue licenses to big game hunters, themselves willing victims of professional hunting firms, when all the evidence already in dictates that the species for which the license is issued will soon be extinct – can such governments command the respect of the world community? Can the insignificant income from such activities really mean the difference between survival of a country and non-survival? We think not.

Has the technological cruelty that we have cleverly invented protect *any* of us from the extinction that we have brought about for our fellow creatures? When the deserts' wildlife is gone – pour le sport, or indeed for food – will the deserts be more useful for man's needs, much less his enjoyment? We think not.

In the twentieth century, our increasing contempt for life, initiated by our overwhelming capacity to destroy life, is bringing closer the day when our world will be despoiled and plundered irrevocably. Today the impala, tomorrow the desert world's wretched humans. What difference?

So we say angrily and bitterly, without apology, viva la cucaracha!

– *Patricia Paylore*

MAN'S PAST AND FUTURE IN ARID LANDS: AN ANTHROPOLOGICAL PERSPECTIVE

by

Theodore E. Downing[1]

To grow or not to grow? To encourage or discourage industrialization? To support large-scale irrigation projects or not? These and similar questions are crucial issues currently facing the citizens of arid lands not only in the United States but also in the Middle East and sub-Sahara Africa. Because the gravity of these issues demands that scientists and policy makers keep their field of vision as clear as possible, perhaps an anthropological outlook can assist in placing contemporary issues in the longer time perspective of man's different adaptations to arid conditions.

Theodore E. Downing
— *Helga Teiwes (1976)*

Early Adaptations

Food collecting has been man's most stable adaptation to arid lands. Either directly through human efforts, or indirectly through the use of animals, man has been a food collector, since over 90 percent of the several billion humans who have lived on this earth since the dawn of man have been hunters, herders, or food collectors.[2] More recently, that is within the past few thousand years, the agricultural revolutions forced the few remaining food collectors into the most marginal arid and tropical lands. Early anthropologists propagated the misimpression that these marginal peoples eke out their subsistence in a constant struggle for food.

We were wrong.

New evidence reveals that even with marginal environments, contemporary food collectors have considerable leisure.[3] It has been found that primitive food collectors provide for *all* their subsistence needs working less than four hours a day! This primitive affluence is restricted by several conditions including a low standard of living, constant exposure to the elements, limited human wants, and an exceedingly low population density. Moreover, it requires constant moving from one area to another as the renewable resources are temporarily exhausted.

Farming, the second preindustrial adaptive strategy, primarily refers to the irrigation of floodplains in arid zones using surface waters. This adaptation increased man's affluence and allowed him a more sedentary life. Preindustrial irrigation has not been without difficulties, however, as salinity problems and waterlogging have helped lead several great civilizations into extinction in both the Old and New Worlds.[4] These early arid land civilizations also faced an additional difficulty: the provision of fuel sources for the increased demands of pottery and metal work that accompanied the sedentary life made possible by irrigated agriculture. Mohenjo-Daro, an ancient city in southwestern Asia, found its immediate hinterlands increasingly deforested as demands for high-temperature kindling increased with the complexities of human material wants.[5] Once one of the world's most advanced civilized cities, today it is an archaeological ruin. In the short run, man may reclaim the desert, but in the long run man himself is outdone.

Two factors appear to have held these early adaptations in check: a low transport efficiency (high cost to move goods) and low storage efficiency (high cost to store products). Both factors restrained the extent of man's search for food and energy to a limited range. This meant that preindustrial adaptations captured little energy outside their immediate surroundings and depended primarily on long distance trade in luxury goods. Arid zones in the preindustrial period, from the perspective of energy exchange, were (and a few still are) closed systems.

Industrial Adaptations

Industrialization was a temperate zone revolution requiring vast quantities of raw materials and energy. Its impact on arid lands was delayed for at least a century while energy was being tapped within the immediate hinterlands of industrialized regions. Transport and storage efficiency and the demand for arid zone energy sources were still too low to make their exploitation profitable. These inefficiencies and demands quickly changed with the invention of the railroad and internal combustion engine. As resources near the great industrial centers of Western Europe and the United States became limited and expensive, the expanding industrial areas stretched

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1. Research Specialist, Bureau of Ethnic Research, and Assistant Professor of Anthropology, University of Arizona, Tucson.
2. Lee, R.B., and I. DeVore, eds. (1968). Symposium on Man the Hunter, University of Chicago, 1966. Aldine Publishing Co., Chicago. 415 p.
3. Lee, R.B. (1968). What hunters do for a living, or, How to make out on scarce resources. *Op. cit.*, p. 30-48.
   Woodbury, J. (1968). An introduction to Hadza ecology. *Op. cit.*, p. 49-55.
   Sahlins, M.D. (1972). Stone Age economics. Aldine-Atherton, Chicago. 348 p.
4. See articles by R. Adams, S. Neely, M. Gibson, and B. Spooner (1974) *in* T.E. Downing and M. Gibson, eds., Irrigation's impact on society. University of Arizona Press, Tucson, Anthropological Papers, No. 25. 181 p.
5. Whyte, R.O. (1961). Evolution of land use in south-Western Asia. *In* L. Dudley Stamp, ed., A history of land use in arid regions. UNESCO, Paris, Arid Zone Research 17:57-118.

giant umbilical cords–rails, highways, and pipelines–into arid zones. The age of extraction began.

The extraction adaption consisted of transferring energy, resources, and materials from arid zones to temperate areas for industrial use. This adaptation produced social patterns distinct from the preindustrial adaptations of food collecting and irrigated agriculture. A new type of society emerged, the one-company town, primarily based on the exploitation of mineral deposits, and characterized by a single company which controls most of the social, economic, and political power in those settlements heavily dependent on an extractive economy. The company's powers might include control of banking, transportation, schools, churches, libraries, health care, and commercial stores. In the United States, this economic dependency led Dr. Courtney Cleland to observe that "southwestern man meshes with the national economy of abundance, not with the regional economy of aridity."[6] In nations whose territory was confined entirely to arid zones, this economic dependency has led to economic, social, and sometimes political intervention by nonarid powers into the arid nation's internal affairs.

Other social patterns are common to the extractive phase, including short-lived boom towns, highly mobile populations, and the destruction or marginalization of native peoples who previously inhabited the regions. In sectors of arid zones suitable for large scale irrigation, heavy capital outlays have brought the development of a new style of irrigation farming based on large scale farms employing seasonal labor. The tapping of groundwater resources has permitted an earlier subtype of food collection adaptation, nomadic herding, to increase to levels adequate to make vegetation rather than water the key limiting resource on herd size.

Intra-zonal energy demands increased greatly, but most of the flow of resources and energy was for export to nonarid lands. Arid zones acquired a reputation for being lands of hidden wealth. As Antione de Saint Exupery's infamous *Little Prince* suggests, "What makes the desert beautiful . . . is that somewhere it hides a well." Man's demands on arid lands were strongly influenced by a perspective and ideals based upon temperate zone experiences, including what constituted a "good" society for arid lands. Under this moral scheme, the instability of settlement and the sensitivity of intra-arid developments to extra-arid zones were considered the antithesis of a good society. The ideal was expressed by desires for another form of social adaptation.

This new social ideal emerged, based on the philosophy of "self-sufficient adaptation." Arid man began his search for a viable, socio-political and economic organization that would be less dependent upon the instabilities inherent in an extraction-based economy. On the ground, this idealism meant building permanent settlements based upon agriculture, industry, trade, and in some cases, tourism.

The belief in the possibility of self-sufficient adaptation for all arid lands was strengthened by a handful of success stories: the southwestern United States, Israel, and Kuwait. These cases, however, were oddities brought about by an enormous influx of capital generated either in nonarid sectors within the country, or resulting from a favorable balance of payments whose ultimate sources were the extractive industries. Following the second World War, the optimism for self-sufficiency was further stimulated by the emergence of an international community of scientists and engineers interested in arid lands development. More than one arid lands scientist has felt that the arid zones have begun to "shake off the shackles of the extractive economy."

The lesson from the past, however, suggests that an epitaph for extractive adaptation to arid zones may be premature. This lesson has been that the social future of arid lands is heavily dependent on outside factors. Discovering the future social and economic patterns of arid zones should begin with a consideration of what future demands placed on them by the rest of the world will be.

Arid Lands in World Perspective

It is becoming increasingly clear that world demands for food and nonrenewable energy will create greater and greater extractive demands on arid lands.[7] Arid lands (and humid tropical lands) will be asked not only to fee and fuel themselves, but also to assume part of the burden for the rest of the world. The future relationship between nonarid and arid powers may become one of parasitism, with arid lands being *the host,* rather than symbiosis some had hoped for.

Above all, the exact demand for arid zone resources by the nonarid world depends on how the consumers of energy in nonarid zones solve their own technological and social problems so that they need not depend on arid zone sources. The demand will also depend on technological innovations developed by arid land scientists and engineers. Many of these future technological developments, such as low-cost solar refrigeration, transportation, and electricity, might serve only to improve the abilities of nonarid zone people to extract energy from arid regions. Such innovations may prove to be technological demons to those engineers and scientists whose goal is to improve the self-sufficiency of arid lands. On the other hand, these innovations may be viewed as blessings which drastically increase employment in the extractive industries. Whichever perspective is taken, the futures of Arizona, New Mexico, Saudi Arabia, and Libya are inexorably linked to decisions of consumers in New York, Illinois, Japan, and Germany.

6. Cleland, C. (1966). Do we need a sociology of arid regions? *In* J.W. Bennett, ed., Social research in moisture-deficient regions. American Association for the Advancement of Science, Southwestern and Rocky Mountain Division, CODAZR Contribution 9, p. 9.

7. Meadows, D.H., *et al.* (1972). The limits to growth. A report for the Club of Rome's project on the predicament of mankind. Universe Books, N.Y. 205 p.

The overall pattern seems clear. Arid lands have moved from an early condition of self-sufficiency into increasing dependence on nonarid regions. This trend is reversing, and now arid regions are becoming increasingly crucial to the world's future demands for food and energy. The goal of self-sufficiency for arid regions stressed by some planners and implied in technological schemes is coming into direct conflict with world demands for their energy and resources. What appears important is that each technological scheme, each innovation, and each opportunity should be carefully evaluated not only as to its ecological and economic impact on arid lands, but also as to its long range social impact on those who call an arid land home.

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WEST AFRICA CONFERENCE

The University of Arizona, under the auspices of the Arid/Semi-Arid Natural Resources Program and the Ghanaian Council for Scientific and Industrial Research (CSIR), cosponsored a West Africa Conference in Tucson in April 1976, to discuss problems of natural resources development and management in the countries of West Africa, and their related social, economic, and political constraints. While the Sahel region has been experiencing severe drought conditions that have disrupted traditional demographic patterns and regional economies, other countries in the semi-arid tropics have also begun to be affected. Topics discussed included historical perspectives, the use of natural resources, increasing population, agricultural practices, physical geography, and land degradation.

Visitors to this conference from out of country included:

K.B. ASANTE, Ghanaian Ambassador to Belgium.

Albert BALIMA, Economic Counsellor to the President, Ouagadougou, Upper Volta.

Albert BARON, Regional Development Officer, AID, Niamey, Niger.

John BUURSINK, Project Manager, Interafrican Committee for Hydraulic Studies, Ouagadougou, Upper Volta.

Neil CARPENTER, Chief of Farm Management, Agricultural Services Division, FAO-Rome.

Robert DODOO, Secretary, Planning and Analysis Group, Council for Scientific and Industrial Research, Accra, Ghana.

Kobena Gyapea ERBYNN, Department of Economics, University of Ghana, Legon/Accra.

R.J. HARRISON-CHURCH, Department of Geography, London School of Economics.

Samuel E. QUARM, Ghanaian Ambassador to the United States.

A.N. TACKIE, Executive Chairman, Council for Scientific and Industrial Research, Accra.

T. YAGUIBOU, Upper Voltan Ambassador to the United States.

ARID LANDS RESEARCH INSTITUTIONS: A New Edition

The University of Arizona is pleased to announce that the Office of Arid Lands Studies is undertaking a completely revised and enlarged edition of its 1967 directory of arid zone research institutions. Instructions are going out worldwide for submission of entries for this new version, but *Arid Lands Newsletter* takes this opportunity to urge all those agencies not represented in the original edition to communicate with the Office of Arid Lands Studies before December 1, 1976, to insure consideration for inclusion.

FOREIGN STUDENT PROFILES

III: Iosef Weiss

Iosef Weiss
—Patricia Paylore (1976)

I was remembering driving up through the Negev Desert from Eilat one winter evening, listening on our car radio to the Voice of America about our moon landings, and thinking that the surface of that "familiar" heavenly object must be very like what we were travelling through, with the geomorphology of the landscape laid bare as it must have been when the world was new. These fanciful and unscientific thoughts came back to me several years later as I sat in my office in faraway Arizona and talked with Iosef Weiss, a 27-year-old Israeli citizen, now in residence at the University of Arizona as a graduate student in chemical engineering. We talked about the difference between the hauntingly beautiful desert he now calls home, and our comparatively lush Sonoran Desert, with its greater vegetative cover. In my mind I have always thought the Negev corresponded more nearly to our Great Basin Desert, but Weiss reminded me that as far north as Beer-Sheva, the marginal semiarid aspect there is one I should not find strange.

During his undergraduate years at the Ben-Gurion University of the Negev, where he obtained his B.S. degree in Chemical Engineering under Professor David Wolf, he lived with his emigre Rumanian parents, which led our conversation back to "Old Town" Beer-Sheva where our mutual recollections of the most marvelous Rumanian restaurants there made us both hungry.

Typical Negev landscape near Arad.
—Patricia Paylore (1972)

Dead Sea.
—Patricia Paylore (1972)

Eyn Avdat, Negev.
—Patricia Paylore (1975)

In a more serious vein, I brought up the presence of the great Research and Development Authority associated with the Ben-Gurion University that emphasizes the commitment of the State of Israel to the development of the Negev and its resources for industrial uses. Potash from the Dead Sea Works and phosphate deposits inland are examples of those applications of desert technology for which the R&D Authority has responsibility.

But not to be overlooked is the academic training at the Ben-Gurion University in such fields as chemical engineering that underwrites this development technically, and Weiss spoke gratefully of the skills imparted to him there that enabled him to slip into a tough sophisticated graduate program here such as transport phenomena, mass transfer, and thermodynamics, without missing a beat.

The existence on the University of Arizona campus of the Negev Committee, together with its counterpart, the Arizona Committee on the Ben-Gurion University campus, helps create a situation within which the many problems in common can be reviewed in the context of faculty-student exchanges and coordinated research efforts. Weiss' Israeli mentor, David Wolf [see Visitors, this issue of the *Newsletter*], is chairman of the Arizona Committee, and his good offices in serving as liaison between our institutions helped bring Weiss here for his graduate work.

Iosef Weiss and his charming Israeli wife are typical perhaps of the enormous reservoir of brainpower potential at the service of the State of Israel, and their determination to contribute to a peaceful and stable society there. The development of the Negev will depend on the knowledge and dedication of such students. We hope that this couple will remember the Sonoran Desert after their return home with the same sense of a shared environment and landscape that we remember the Negev.

– PP

VISITORS PARTICIPATING IN THE DESERTIFICATION SEMINARS

The University of Arizona's 211(d) Natural Resources Program conducted a 14-week series of seminars on *Desertification: Process, Problems, Prescriptions,* November 1975-April 1976, that took advantage of visiting and invited scholars as well as its own faculty to cover a wide-ranging look at the topic. Dr. Harold E. Dregne, Director of Texas Tech University's ICASALS, spoke on the subject as a "symptom of a crisis"; and Dr. Sherwood B. Idso, Research Physicist with the U.S. Water Conservation Laboratory, Phoenix, Arizona, took up desertification from the view of the effects thereon from atmospheric dust and surface albedo.

Ian Douglas points out to Director Jack D. Johnson, Office of Arid Lands Studies and Program Director of the Natural Resources Program, an area in Australia subject to desertification.

— Patricia Paylore (1976)

Two other visitors presented case studies: Ian Douglas, Professor of Geography, University of New England, Armidale, New South Wales, speaking on desertification and the salinity problem in Australia; and Dr. Harold F. Heady, Associate Dean, College of Natural Resources, University of California, Berkeley, who described "a desert repaired" in southeastern Oregon through a successful Bureau of Land Management program of range rehabilitation.

Other authors than the visitors noted above include the University's Terah L. Smiley, William G. McGinnies, W. Gerald Matlock, William B. Bull, Bernard L. Fontana, and Julian D. Hayden. All papers have been edited for publication and are available at $15.00 per copy from the University of Arizona's Office of Arid Lands Studies, 845 North Park Avenue, Tucson, Arizona 85719, USA. It carries a publication date of 1976, is illustrated by numerous photographs, and runs to 125 pages.

NEW ARID LANDS PUBLICATIONS:
A Random Selection

BREAD FROM THE DESERT. 1976. Scala, special issue [English edition], p. 20-25.

Popular account of engineering activities sponsored by the Federal Republic of Germany designed to create what are called artificial irrigation systems involving extensive net awnings of varying thicknesses over cultivated areas, climatized domes, and novel shade-providing tent roof designs. Illustrations show helicopters ferrying in prefabricated components to distant deserts without adequate transportation systems.

DESERTIFICATION: A WORLD BIBLIOGRAPHY. ©1976. Compiled and edited by Patricia Paylore for the International Geographical Union's 23rd Congress, Moscow, 1976. University of Arizona, Office of Arid Lands Studies, 845 North Park Ave., Tucson, Arizona 85719, USA. 644 p., paper. $21.00 US, or $25.00 for foreign orders shipped air parcel post.

Consists of 1,750 citations, most with abstracts, produced from the OALS computerized Arid Lands Information System. Divided into regions covering the Sahara-Sahel, East Africa, southern Africa, the Middle East, the USSR, Pakistan, India, China, Australia, and South and North America, with regional introductions by world experts. Maps.

Eckholm, Erik P. 1976. **LOSING GROUND. ENVIRONMENTAL STRESS AND WORLD FOOD PROSPECTS.** Foreword by Maurice F. Strong. Norton, N.Y., 223 p.

Jointly sponsored by the United Nations Environment Programme and the Worldwatch Institute, this anguished book vividly documents the global extent of ecological stress, its political causes, and its human consequences. The author calls for massive tree-planting campaigns, agricultural reforms to benefit peasant farmers, and a slowdown in world population growth, predicting that unless there is a major shift in global political priorities, a third of mankind will become mired in hopeless destitution, a tragedy with ominous implications for world order. Global food shortages with attendant inflation will undoubtedly intensify if the undermining of food-producing systems is not arrested. Special attention is devoted to deforestation, desert encroachment, salting/silting of irrigation systems, and the third world fuel crisis triggered by increasingly scarce firewood.

Firouz, Eskandar. 1974. **ENVIRONMENT IRAN.** National Society for the Conservation of Natural Resources and Human Environment, Tehran. 51 p.

Iran is one of the most advanced countries in the Middle East in the area of environmental protection. The author is Director of the Department of the Environment, and in this slight and charming book, beautifully illustrated with his own photographs, he states the firm determination of the country to implement an action program to recognize and protect the aquatic ecosystems, preserve habitats, manage the country's enormous arid lands through conservation, environmental engineering, and monitoring. A little recognized aspect is the bilateral arrangements made with countries with which Iran shares some of these unusual and historic preserves. Maps.

Gomez-Pompa, A., and A. Butanda C., eds. 1975. **INDICE DE PROYECTOS EN DESARROLLO EN ECOLOGIA TROPICAL** (Index of Current Tropical Ecology Research), vol. 1. Instituto de Investigaciones sobre Recursos Bióticos, A.C., H. Colegio Militar No. 7 ó AP-63, Xalapa, Ver., México. 227 p.

A directory of over 500 names of specialists in tropical ecology, including the following additional information about each: title of project, objectives, date of initiation and probable date of completion, name of institution responsible for the research, names of scientific personnel participating locally, citation of most recent contribution on the subject, and country or region where the research is being carried out. Computerized geographical index of authors, name index of authors, and two keyword indexes, English and Spanish.

Goodall, David W., ed. 1976. **EVOLUTION OF DESERT BIOTA.** University of Texas Press, Austin & London, 250 p.

Papers explore evolution of animals and plants on the deserts of North and South America and Australia, and their adaptations to these environments.

Goodman, Gordon T., and Shirley A. Bray. 1975. **ECOLOGICAL ASPECTS OF THE RECLAMATION OF DERELICT AND DISTURBED LAND.** An Annotated Bibliography. Natural Environment Research Council, London/Geo Abstracts, Ltd., Norwich. 351 p.

A bibliography of over 1,500 citations, with annotations, relating to problems of establishing and maintaining vegetation on derelict land in the north temperate region which has been disturbed or polluted by urban or industrial activity. Categories include coalspoil, acid mine drainage, bauxite, sand and gravel (including sand dunes), domestic refuse and sewage disposal, disused airfields, bombing ranges, canals and railways, soil erosion, and several other specific waste materials or substrates. There is an accompanying "commentary" that gives definitions, discusses the extent of damaged land, why damaged land is a problem, why derelict land is not reclaimed faster, the importance of revegetation, a survey of revegetation problems, and the physical and chemical factors inhibiting plant growth. There is a computerized subject index of keywords-in-title, plus an author list.

Israel, Prime Minister's Office, Environmental Protection Service. 1975. **SELECTED PAPERS ON THE ENVIRONMENT IN ISRAEL.** 3 Hakirya Bldg., 3, Jerusalem.

This issue includes a comprehensive listing of Israel's environmental laws, plus an article by Ralph Mitchell of the Weizmann Institute on "Environmental Deterioration in Israel."

Kelly, Kathleen, and R.T. Schnadelbach. ©1976. **LANDSCAPING THE SAUDI ARABIAN DESERT.** Delancey Press, Philadelphia. 182 p.

Includes chapters on the Saudi Arabian Desert, its water, climate, geology and topography, vegetation, and desert wildlife. Factors important for landscape design are wind, sun and heat, and water; elements organic to landscape construction are soils, irrigation, and maintenance. The extensive section on recommended plants includes under each species information on its uses, its wind resistance qualities and water requirements, with black-and-white photographs of many. The appendices include a discussion of ecological communities, and a list of more than 180 species known to have been observed growing naturally in Saudi Arabia or cultivated there long enough to have developed local strains. Bibliography.

National Academy of Sciences. 1975. **UNDEREXPLOITED TROPICAL PLANTS WITH PROMISING ECONOMIC VALUE.** Available NAS Commission on International Relations (JH 215), 2101 Constitution Ave., Washington, D.C. 20418, USA. 188 p.

The 36 plants described, selected from among 400 reviewed, were chosen on the basis of several criteria: Can it be grown in the tropics? Does it have significant potential as a source of food, forage, or industrial raw material? Can it help make developing countries (or areas within them) more productive? Divisions are: cereals, roots and tubers, vegetables, fruits, oilseeds, forage. Each plant within these categories is described, its limitations and special requirements, and research contacts and germ plasm sources noted. Arid lands species include buffalo gourd, jojoba, *Acacia albida, Cassia sturtii,* saltbushes, and guayule. Resumes in French and Spanish.

River Niger Commission, Documentation Centre. 1975. **INDEX OF THE RNCDC,** No. 1. B.P. 933, Niamey, Niger. 273 p.

The Commission is responsible for the collection, analysis, and circulation by means of this index, of documentation of use in the economic and social development of the Niger basin. Included: a bibliographical listing giving references and indexing synopsis for each document, a computer-produced analytical index (KWIC), and an author index. Available in both English and French. The 2d vol. is due later this year.

Ruiz Leal, Adrian. 1972 [received 1976]. **FLORA POPULAR MENDOCINA.** Special issue of Deserta, No. 3, Instituto Argentino de Investigaciones de las Zonas Aridas, Casilla de Correo 507, Mendoza, Argentina.

U.S. Atomic Energy Commission, Office of Information Services, Technical Information Center. 1974. **SOLAR ENERGY,** A Bibliography. Reprinted by ERDA. Available National Technical Information Service, Springfield, Virginia 22161, TID-3351. 356 p. $10.60 paper.

Over 3,500 citations on the economic use of solar energy in the generation of electricity and for heating and cooling of buildings. References are arranged in broad subject categories, including site geology and meteorology, economics, environmental aspects, conversion, photovoltaic powerplants, solar thermal powerplants, ocean thermal gradient powerplants, solar radiation use, and solar collectors and concentrators.

Université Louis Pasteur, Strasbourg, U.E.R. de Géographie. 1975. **TYPES DE CROUTES CALCAIRES ET LEUR REPARTITION REGIONALE.** Comptes-Rendus du Colloque, Strasbourg, 9-11 janvier 1975. 146 p. + 8-page bibliography laid in. 25F.

Papers on structure and petrography, micromorphology and pedology, processes and genesis, and regional distribution, with examples from Israel, Morocco, Spain, Algeria, Afghanistan, and Senegal.

Wehmeier, E. 1975. **DIE BEWAESSERUNGOASE PHOENIX, ARIZONA.** Stuttgarter Geographische Studien 89. 176 p.

Starting from the premise that ecological imperatives often are superseded by economic imperatives, this author develops the following ideas relating to the irrigated "oasis" of Phoenix: irrigation agriculture is the only possible form of crop production within the oasis; different methods of irrigation result solely from variability of crops rather than terrain; degrees of soil salinity seem not to have had any significant impact on cultivation of specially adapted crops; the effects of intensive urbanization on the irrigated areas and on the water balance of the oasis are shown; and finally, the possibility of extensive Indian irrigation agriculture around the periphery of the oasis in future is explored as a trend of importance for increased food supplies for an expanding oasis.

Weise, O.R. 1974. **ZUR HANGENTWICKLUNG UND FLAECHENBILDUNG IM TROCKENBEBIET DES IRANISCHEN HOCHLANDES** (Contributions to slope development and plain formation in the deserts of the Iranian highland). Wuerzburger Geographische Arbeiten, 42. 382 p. + portfolio of maps.

Landforms in Iran may be divided into those regions with basin-and-range structure and young tectonic movements (especially high mountains with bajadas in the forefront), and those in the so-called Lut block, a relatively stable region on which extensive pediplains and desert domes are developed. In the deserts, slopes are formed chiefly by areal fluvial degradation and weathering. The erosional processes affect mountains, mountain rims, cuestas, and their surroundings equally, with the levelling plain formation from the interior of the mountains having its greatest effects.

VISITORS FROM OUT OF COUNTRY

February 1976
SPOONER, Brian
Division of Human Environment
Department of Environmental Conservation
Tehran
Iran

April 1976
PENA, Carlos
Director of Coordination
National Council for Science & Technology
Mexico, D.F.

April 1976
PUEBLA, Manuel
Associate Technical Director
National Council for Science & Technology
Mexico, D.F.

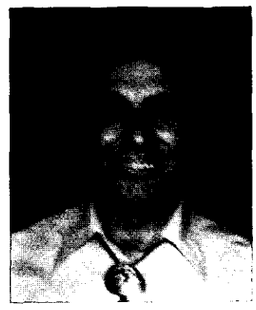
May 1976
SAID, Rushdi
Director, Geological Survey of Egypt
Cairo
Egypt

May 3, 1976
ABU-IZZEDDIN, Faisal
Livestock Consultant
Badieh
Lebanon

June 1976
WISNIAK, Dr. Jaime
Ben-Gurion University of the Negev
Beer-Sheva
Israel

June 14, 1976
DIEKO, Ibrahima
Economic Counsellor to the President
Bamako
Mali

July 6, 1976
DELIMIROVIC, Dr. Boris
Chief, Field Office US-Mexico Border
Pan American Sanitary Bureau
El Paso, Texas



July 14, 1976
WOLF, Dr. David
Department of Chemical Engineering
Ben-Gurion University of the Negev
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Israel

July 27, 1976
SCHICK, Dr. Asher P.
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BRAUN, Rolando H.
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DALIN, Moseph S.
Head, Flood Water Utilization Department
TAHAL – Water Planning for Israel, Ltd.
Tel-Aviv

August 13, 1976
AL-KUBAISI, Mohamed
President
Organization of Soil & Land Reclamation
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August 13, 1976
HANNA, Dr. Augustine B.
Director General, Scientific Research
State Organization of Soils & Land Reclamation
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Iraq

August 17, 1976
RIMAWI, Dr. Walid
Chairman, Civil Engineering Department
University of Kuwait
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August 18, 1976
Del CASTILLO DAVILA, Tito Javier
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Universidad de Guadalajara
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Mexico

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INTRODUCTION

This paper is an attempt to indicate the extent of the desertification problem in the United States. It includes a historical review of the land-use problems in the arid and semi-arid regions of the United States, discusses some of the current problems and emphasizes the need for concerted and sensible land-use planning and management if the U.S. is to curb its degradation of the semiarid and arid western lands and avoid the creation of deserts in those areas where land is being misused. Desertification is not a problem for the developing countries to tackle alone. Indeed it is a problem which the world must confront. The United States shares this problem, can offer some solutions, and will definitely benefit in the exchange of ideas and methodologies which will be presented throughout and following the U.N. Conference on Desertification.

In addition to the text this paper contains three appendices. Appendix A is an annotated bibliography of reading material, most of which was used in the preparation of the text, although specific references and quotes are not included as a part of the text. Appendix B is a partial list of activities which the U.S. government is either conducting or funding. The list could have included many other activities which are funded or conducted by the Soil Conservation Service, Bureau of Indian Affairs, Department of Commerce, Agricultural Extension Service, state and local governments, universities or other public or private instituitions conducting research. To be all inclusive would require more time than was available, but Appendix B is representative of U.S. activities and interest in desertification.

Appendix C is a summary of this paper in Spanish.

DESERTIFICATION IN THE UNITED STATES

By Jack Donald Johnson

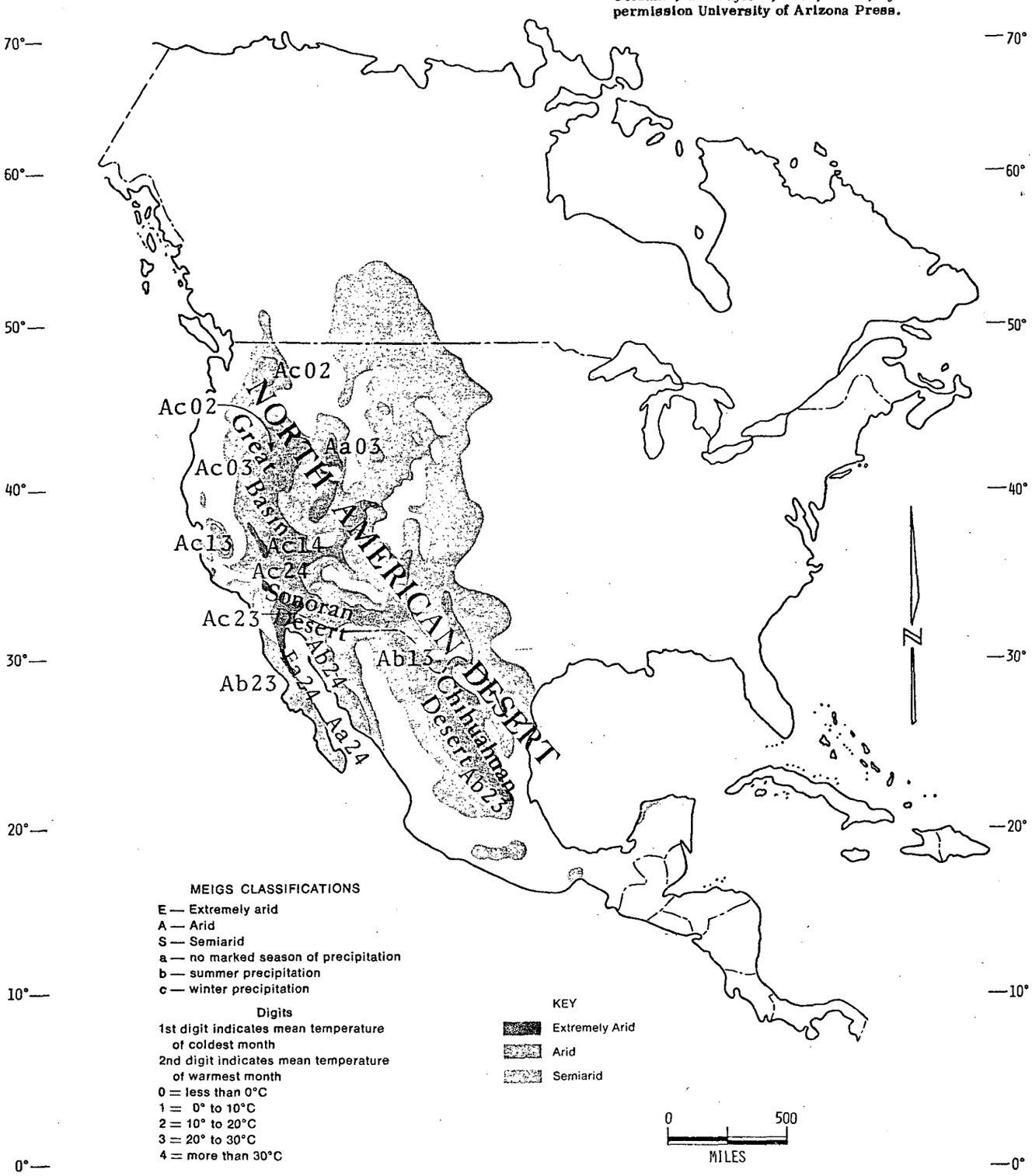
I. OVERVIEW

The total population (based on 1970 census) of the United States presently exceeds 203 million. The population of the 12 western states exceeds 45 million and is a little over 22 percent of the total population of the U. S. These same 12 states comprise about 40 percent of the total land area of the U.S. and almost all of the arid portions of the nation. (See map, page 2.) Approximately 23 million people reside in the arid regions of the U.S.

The 12 western states constitute a land area of about 1.4 million square miles. Seventy-two percent of this land, or in excess of one million square miles, is within the region currently or potentially subjected to desertification processes.

Population growth in the West during the last decade almost tripled that of the eastern states. The combination of 1) immigration, 2) migration from Mexico, north-central states and eastern states to the West, and 3) general population growth because of local birth rates is causing an alarming increase in the population of many of the western states. Land developers, chambers of commerce and individual businessmen expecting financial rewards are advertising and exploiting the arid regions.

In the populous eastern states the population density is high. In New Jersey, for example, there are over 953 people per square mile of land area, and in Washington, D.C. there are more than 12,400. In California, even with its large urban centers, the population density is only about 128, and within the other western arid states the population density is considerably less. For example, Arizona has about 16 and Wyoming about 3.4 people per square mile. This seems to indicate room for growth, but unfortunately growth from the large urban centers is rapidly expanding into the deserts and up into the mountains with little regard for the resources of arable land, water, vegetation and wildlife.



Arid Lands of North America (after Meigs)

Archaeological sites, ghost towns, abandoned ranches and empty farms that dot the arid West are dramatic examples of man's early failure to obtain a balance between his natural arid environment and his desire for expansion. When the earth was sparsely populated or uninhabited, land was abundant; man could abandon old environmental failures and move onto new lands. Today, the situation is much different; with expanding world population it is impossible to abandon or ignore the arid lands of any country.

Within the U.S. 60 to 70 percent of the arid lands are in federal or other public ownership. Some 130 million acres in arid lands states have been placed under multiple-use, sustained yield management within the national forests, which are administered by the U.S. Forest Service. Recent passage of the Federal Land Policy and Management Act has overcome some of the policy indeterminacy of the U.S. public lands, which are administered by the Bureau of Land Management. The new Act addresses the multiple-use and sustained yield management concept through an interdisciplinary land-use planning system.

One of the attributes of the rugged, arid western United States is that one can drive from the hot desert floor or large urban area into the dense mountain forests, often within a matter of minutes and never more than a few hours.

Irrigated agriculture is an important aspect of arid regions, and some irrigated portions of Arizona and California deserts comprise the most productive land in the U.S. It may not, however, be the most desirable or economically efficient use of water, and the expansion of irrigation farming farther into the desert requires a critical review. Much of the arid and semiarid areas is used as grazing land, and some of the arid regions are rich in mineral deposits, particularly in copper and coal. (Over 50 percent of U.S. copper is mined in Arizona.) Energy potential (solar, coal, uranium, oil and gas, and hydroelectric) is being exploited for use in large urban centers, particularly for Phoenix, Las Vegas and Los Angeles.

Recreation is rapidly becoming an important economic use of arid regions in the U.S. Surveys in desert recreational areas of Southern California during 1968 indicated that there were 570,000 people on one-day field trips; 1.1 million overnight trips; and about $30.9 million expended by these recreation users. Projections based on 1968 statistics of 4.9 million visitor days are that Southern California deserts will see 7.8 million visitor days in 1980 and 13.2 million by the year 2000.

One of the recreational uses which has recently received much publicity (mostly negative) is the use of motorcycles, "dune buggies" and four-wheel drive vehicles in remote desert areas. Because of the climatic and biotic conditions, physical scars on the landscape remain for centuries before nature can hide them. (For example, some of the tracks left by wagon trains crossing the arid regions of the western United States in the 1840s are visible today.) The lack of moisture slows natural decay processes and allows discarded waste products and containers to remain almost unaltered for long periods of time. (For example, a discarded paper tissue on the desert floor may remain as a visible symbol of human thoughtlessness for many years.) Pits from mining operations could possibly serve as recreational facilities or as sitss for other industrial development, but usually they simply stand as a reminder that man can dig a big deep hole in the ground.

Desertification, as a definitive process, has received only recent attention in the United States. But if we accept the concern regarding misuse of arid and semiarid lands, desertification concerns began sometime in the 1800s. In 1947 Dr. Walter P. Cottam authored a University of Utah Bulletin (Vol. 37 No. 11) entitled "Is Utah Sahara Bound?" Had he been able to predict today's use of the term "desertification," he might have used some other title such as "The Extent of Desertification in Utah." While economic data have not been researched for presentation herein, desertification does have serious economic impact. Arid land recreation and agricultural land are producers of a significant national income, and any reduction of that income through the desertification process has had and will have national consequences.

A recent disastrous drought of a few months' duration on the Papago Indian Reservation required emergency funds and services from several federal agencies and brought crippling losses of cattle and crops. The earlier experiences of the "dust bowl" in Oklahoma, the land reclamation programs, and the assistance to Indian reservations have totaled billions of dollars--and both the benefits of these expenditures and the burden of these costs are borne nationally. It should be emphasized that the U.S. experiences with desertification, reported herein, should be relevant to other arid and semiarid areas of the world, with the possible exception of some of the recreational uses.

II. HISTORY OF LAND USE IN ARID REGIONS OF THE UNITED STATES

There is evidence that man has lived in the arid and semi-arid regions of the U.S. for as long as 11,000 to 25,000 years, and ecological adaptations to the arid environments indicate a zone of extreme aridity in the Great Plains between about 5500 and 2000 B.C. Evidence from caves in west central New Mexico indicates that the period from perhaps 4000 B.C. to a few centuries before the beginning of the Christian era was a time of life based on cultivation. Established agriculture, however, did not replace the ancient food gathering practices until about 300 B.C. It was with the growth of cultivation and the improvement of agricultural techniques that the American Indian became capable of mastering many of the arid and semi-arid zones of the continent.

Until the middle of the 19th century the vast arid/semiarid region lying between the Rocky Mountains and the ranges bordering the Pacific Ocean was virtually unknown to the anglo. A century earlier Spanish missionaries had penetrated a small part of southern Arizona, introducting cattle to the scattering of Catholic missions they had founded there. They also made occasional trips across the intervening desert to the chain of similar missions along the California coast. These and other travelers, such as trappers and traders, did not write detailed descriptions of their travels; maps were not published prior to the 1840s.

The discovery of gold, which was in 1848 in California, brought tens of thousands of people across the desert region en route to the gold fields, but the arid area still lay virtually empty and unused until the latter part of the 1860s. From the early 1800s through the late 1860s grazing animals were brought into the Southwest by Spanish and Mexican missionaries and cattlemen. In the late 1860s there occurred an influx of settlers, chiefly comprised of cattlemen from the semiarid regions farther east. California presents some interesting statistics regarding sheep population which had increased to 1.9 million in 1860, 2.8 million in 1870 and 4.4 million by 1890. At that time, conditions in the arid West were far from stable and the nation was still recovering from the Civil War. Partially settled western territories were poorly administered, and the military and police forces were inadequate.

The following half century was the era of the open range. Herders laid claim to the widely separated watering places and thus held practical if not legal control over the vast waterless grazing lands. Land tenure was the major problem in the United States. The first attempt at control was the development of a General Land Office as an agency of the U.S. federal

government to administer and apportion public lands of the U.S. Under the Homestead Act of 1862 any citizen could attain title to 160 acres, but this Act was principally created for the purpose of developing the agricultural land of the East and the Midwest. One hundred sixty acres in the eastern and midwestern United States was adequate for maintenance of moderate to high standards of living, but land holdings of such small size were totally inadequate for enterprises in a semiarid or arid pastoral region. In most of the arid regions 160 acres would support no more than two head of cattle.

The Desert Land Act of 1877 provided that title might be obtained to a full section (640 acres), but that Act had only limited effect since it required that part of the land be irrigated. Most of the land in the arid West was not irrigable. In 1879 a federal commission headed by John Wesley Powell turned in its report on the governmental policies concerning the public lands of the arid West. The report stated that... "the Homestead and Preemption laws are not suited for securing settlement of more than an insignificant portion of the country."

Powell's report went on to suggest: 1) that land should be scientifically appraised and classified before settlement and that each category should be handled under laws specifically applicable to it; 2) that land must be disposed of in quantities sufficient to the establishment of working enterprises, and that the price of such a grant must be kept low...at least four square miles (2,560 acres) was proposed as a minimum; 3) that farm and ranch residences be grouped to permit a form of social life not possible on isolated ranchsteads; 4) that surveys should deviate from rectangular systems when necessary to divide irrigation waters properly; and 5) because of the great expense required to develop irrigation, irrigation schemes should be undertaken under the auspices of the federal government.

Unfortunately, no action was taken by the Congress of the United States on Powell's suggestions, which proved to be far ahead of their time.

During the 1890s and on into the early 1900s, particularly under the impetus provided by President Theodore Roosevelt, conservation measures were beginning to evolve. This was a rather stormy period in the grazing land areas where cattlemen fought farmers, sheepmen fought farmers, and cattlemen fought sheepmen. Pitched battles were waged over the right to build fences and section off land. In general the land was heavily overgrazed but the cattlemen were perceived as popular heroes with the "dirt farmer" and sheepmen getting the worst of most battles-- both physically and legally.

The Taylor Grazing Act of 1934 was the first major congressional action aimed specifically at the management of grazing lands of the arid and semiarid West. The Taylor Act was stimulated by the result of a 1932 survey indicating that rangeland productivity had declined by 50 percent and that grass removal had exposed 80 percent of the range to erosion. The Act established grazing districts and created the Grazing Service. Under federal control the number of animals was regulated to approximate a balance between range use and the forage-producing capacity of the land. It was fortunate that the Act was passed and implemented during the depth of the drought and the depression of the 1930s, for during that period the number of animals was already sharply reduced. The government therefore had to face principally the problem of preventing an increase in the animal population rather than having to bring about a drastic reduction. For administrative purposes a system of range inspection and evaluation was inaugurated to check on different stocking and management programs. Although relative stability has characterized the western desert ranges since the late 1930s, many areas are still poorly managed, and attempts at scientific grazing control are often frustrated by the complications of land tenure, multiple use of lands and the ease with which legal actions against agencies can be brought into the courts.

Many settlers migrating from the eastern United States brought their more humid region technology into the arid regions and attempted rain-fed farming. This usually accomplished nothing except to lay the land open to erosion by wind and rain, and in all cases failed to provide dependable crop production.

The development of irrigation in the arid portions dates back to the Hohokam and Pueblo Indians, but it was not until the 1840s that the anglos began irrigated agriculture. Among the first to establish successful irrigation farming were the Mormons in the Salt Lake City area. One of the reasons for their early success was the inseparability in the Mormon philosophy of church and state. Thus, it was relatively easy for them to establish a communal irrigation system and thereby allocate the land and water rights and obligations.

It was during the reclamation era of the 1930s and 1940s that the arid regions saw the harnessing of most of the major streams originating in the mountainous West. This resulted in multipurpose dams and the extension of irrigation to vast areas of the desert and semidesert.

Other land uses in the arid Southwest included Indian reservations, large urban centers, electrical energy production, mining and industrial development, and recreation.

III. RANGE RESOURCE UTILIZATION

As a result of the severe overgrazing which occurred during the late 1800s, the U.S. government has attempted to develop range control on its publicly owned land. Private, state-owned and Indian lands are not under federal grazing control, but through the Agricultural Extension Service associated with the Land Grant colleges and universities many improved range management techniques have been and are being adopted on non-federal lands.

Both the U.S. Bureau of Land Management and the U.S. Forest Service lands are grazed, in keeping with the multiple-use management concept. Multiple use may include recreation, timber production, mining, water resource development, transportation and power production. While multiple-use policy has its obvious advantages, it also leads to complications for the range manager. Range scientists are as yet unable to predict accurately the synergistic effects of multiple use on the carrying capacity of the land.

While severe overgrazing is generally prevented on most public lands, the result of multiple use is that the associated impact on range vegetation and soil requires continual assessment and re-evaluation of carrying capacity. Land tenure also complicates the problem in the U.S., as grazing may occur in a geographical area which involves land in which various parts are owned by the U.S. Forest Service, the U.S. Bureau of Land Management, Indian reservations, the states or private parties. The Indian reservations are generally severely overgrazed, and control of animal numbers is through tribal councils or cattlemen's associations. Indian cattlemen are reluctant to reduce herd size because to many the existence of a large herd is a source of savings, community power, influence and prestige.

Most range scientists agree that many of the public and private lands are being degraded, and that controls must be stepped up. There are many well-documented historical cases in which overgrazing caused the invasion of low woody plants of little nutritive value, the acceleration of erosion processes and depletion of groundwater.

Western cattle ranches today average over 20,000 acres with a carrying capacity of about one grazing cow per 100 acres. The economic stability brought to the desert ranch is largely a result of the transportation system, the development of water well drilling and pumping equipment, and the application of modern scientific methods in range management, breeding, feeding, veterinary medicine and marketing.

IV. IRRIGATED AGRICULTURE

Irrigation has literally transformed many parts of the deserts of the arid Southwest into agriculture production centers. Irrigation has, in the U.S., contributed to the desertification process via its consumptive use of scarce water supplies, salinization of soils, and, occasionally, the retirement of these agricultural lands to become barren wastelands.

The water problem is most critical in areas in which groundwater is being consumed faster than the rate of recharge to the groundwater system. Several streams and rivers that once were perennial are now ephemeral. This problem is particularly acute in those parts of the semiarid Southwest where groundwater is the only source of water. In the Santa Cruz Valley in southern Arizona, for example, water withdrawal for the urban center of Tucson, for irrigated agriculture and for mining copper is so far in excess of natural replenishment that the groundwater level has declined 200 feet or more in some areas.

One of the problems facing the irrigation farmer, who depends upon a declining groundwater supply, is that he must not only incur steadily increasing costs associated with the energy required to pump from ever-greater depths, but the rapidly increasing cost of energy itself. This places farmers in a position of exponentially rising costs and has caused many of them to abandon their lands. This abandonment of formerly productive agricultural lands leaves vulnerable top soil, which is often saline and does not naturally revegetate with low rainfall. As a result, the barren land serves primarily as a producer of windblown dust and sand. So severe is this problem that many motorists on the highway between Tucson and Phoenix have perished in auto accidents caused by blinding duststorms. This highway now has special sensor signs posted to warn travelers when duststorms are anticipated.

The salinization of soils is, of course, a well-known process associated with irrigation which may contribute to desertification. The general solution to the problem within the U.S. is simply to apply sufficient water to leach out the salts through a subsurface or well drainage system. While the solution clearly solves the problem locally, it results in other complications. It creates a downstream leachate that is higher in dissolved salts than the upstream waters, and, as our friends in Mexico are keenly aware, when the return flows are cycled through several uses, the end user receives water which may be too laden with salt to grow many crops. The Colorado River below Yuma, Arizona is just such an example, where the U.S. is now in the process of building a 100 million-gallon-a-day desalting plant.

Land abandoned because of salinity problems presents special difficulties in reclamation or revegetation with native plants. One of the greatest challenges of the future, one that numerous civilizations have failed to meet, is dealing with the effects of long-term arid lands irrigation.

V. MINING

While not particularly extensive in areal terms, mining can create a virtual desert locally. Mine reclamation is a field now receiving considerable attention. The effects of mining are different, depending upon the method and the ore body. This paper will discuss only two of the more obvious mining activities that have stimulated considerable public awareness.

Copper mining is extremely vital to the economy of Arizona, and it constitutues the major industry of the state. Most of the copper is mined in open pit operations that may be several square miles in top area and about 800 feet deep. There are several of these huge holes in the Arizona landscape, and the removed overburden plus evaporation ponds, holding processing wastes, create relatively large unproductive areas around the mine.

Architects have looked at the possibility of locating housing developments on the overburden, but for now they lie as unused waste, a tribute to man's ability to move a lot of dirt. This may be called desertification, but in general it is a local phenomenon and does not spread beyond the mine operation. Its visual impact is felt by residents or visitors for miles in all directions. The depletion of water resources required for milling may involve nearby or distant aquifers.

Coal mining in Arizona, Utah, Colorado, New Mexico, Montana and Wyoming has the potential to lay waste large areas. To date, strip-mining reclamation has had only sporadic success. The Four Corners area in New Mexico has such highly alkaline overburden that revegetation has failed, but in the Black Mesa area of Arizona and in parts of Montana and Wyoming strip-mine revegetation has been more successful. Huge deposits of coal and oil shale exist in the West, and exploitation seems inevitable. Many U.S. citizens, non-governmental agencies and governmental organizations are concerning themselves with the environmental impact of this exploitation, especially that which is related to the ~~coal~~ shale deposits that have both huge energy potential and huge land degradation potential. Recklessly approached, ~~coal~~ shale mining has the potential to desertify large expanses of land.

VI. URBANIZATION

Urban development may be one of the best uses of arid and semiarid lands, if proper planning and common sense accompany such use. While wasteful and improper water use in these cities may ultimately lead to ghost towns or concrete deserts, the most publicized problems are those caused by thoughtless land developers who carve up dry desert areas with roads in an attempt to sell these arid plots of waterless land to gullible easterners and midwesterners. A flight over New Mexico, Arizona and Nevada will reveal hundreds of these unpaved roads simply cross-hatching the land with no housing at all. On the ground one sees that many of the "streets" have become gullies which carry away the thin topsoils that typify the arid areas.

Another problem associated with urbanization is the demand for water and land. These demands often force agricultural lands to be retired, either to housing, as in the Los Angeles and Phoenix areas, or to simply unused lands so that the groundwater resource can be used by the city dwellers. Part of the once agriculturally rich Avra Valley in southern Arizona is in the process of becoming a wasteland and potential source of windblown sand and dust, because Tucson needs the groundwater resource for its increasing population. Population growth with the attendant demands for scarce resources is the basis for most arid lands problems.

Many of our western arid and semiarid areas were originally developed for irrigated agricultural usage. Recent population increases (largely attributable to the desirability of the climate for living), reductions in groundwater levels and quality, and increased costs of energy for high-technology agriculture that typifies these areas suggest that U.S. arid lands are on the threshold of a revolution in usage patterns.

VII. RECREATION

The plentiful sunshine of the arid regions, the general affluence of the average U.S. worker, plus more and more spare time have created an interesting and bothersome land degradation problem. As previously mentioned, motorcycles, "dune buggies," four-wheel drive off-road vehicles and campers have invaded the desert areas, and they leave their marks.

Although widespread, this problem is particularly acute in the Mojave and California deserts, on federal lands administered by the Bureau of Land Management. Eleven million Southern Californians view this unreserved public domain as "their own backyard." Use of the area by off-road vehicles was unregulated until 1972. During one 12-month period there were 151 organized competitive racing events for off-road vehicles involving more than 67,000 participants and 189,000 spectators.

The most extraordinary of the "scramble" races was run each Thanksgiving weekend over a 160-mile course between Barstow, California and Las Vegas, Nevada. Three thousand motorcyclists spread across the desert, traveling at breakneck speeds as they compact the soil, devastate vegetation, stir up clouds of dust and terrorize wildlife. The long-term results of such activities have been denudation of significant patches of the landscape. The Bureau of Land Management has subsequently canceled the races, but the damage remains.

VIII. PHREATOPHYTE AND OTHER VEGETATION CONTROLS

The demand for water resources in arid areas is always greater than the supply, causing agricultural, mining and municipal planners to be constantly devising new schemes for diverting larger portions of the limited water resources through the human portion of the desert ecosystem. Recently great concern has been expressed about phreatophytes. Rivers and washes, the arteries of our watersheds, are frequently bordered by stands of tall trees in significant riparian communities. Many of the trees are heavy water users, phreatophytes, and their elimination has been advocated in some areas. Phreatophyte control programs frequently include channeling water courses.

It has also been noted that vegetation could be stripped from several million acres of Arizona forest and desert (largely chaparral vegetation) to increase water runoff. Such schemes to remove large tracts of vegetation are possibly ill-advised because of the long-range degradation and desertification potential. In the short term, increasing water runoff through vegetation removal may mean less water infiltrating to groundwater, and sediment may accumulate more rapidly in water catchments and reservoirs.

IX. SUMMARY

While desertification is a relatively new term in the U.S. scientific vocabulary, land and resource misuse and degradation are not. Desertification is indeed a serious problem, with overgrazing, salinization of soils, depletion of water resources, land subsidence, population pressures, abandonment of lands, some mining operations, and destruction of vegetation or desert pavement through careless recreation, and other exploitations of the desert resources all contributing factors.

To ignore the impact of desertification on the U.S. is a mistake. While very high-level U.S. technology (and capital expenditures) has tremendous capacity to produce, it has equally tremendous capacity to destroy. If resource planners and managers, private investors and government regulatory agencies do not establish and maintain awareness and vigilance of land degradation in the Southwest, desertification could become a problem of increasing national impact. We have the technical knowledge to control and in some instances to reverse the land degradation, but as in many countries the pressures from a too rapidly increasing population coupled with the social problems of implementing known technology do not permit a careless optimism.

It is for these reasons that U.S. government agencies have undertaken a variety of activities aimed at control and possible reversal of arid lands degradation. For instance, in 1968 the Bureau of Land Management launched a California desert study. Its purpose was to inventory current and prospective land uses in the first step toward introduction of integrated management. The study focused public attention on management needs of the fragile arid lands environment creating a gradual increase in management awareness. As part of the Federal Land Policy and Management Act, the Bureau of Land Management has been directed to effect an interim management plan pending development of a comprehensive multiple-use, sustained yield plan for the Southern California desert conservation area. The interim plan will emphasize orderly public use and authorizes a patrol to ensure public safety and to enforce orderly use of the lands. The comprehensive plan will be developed through the Bureau of Land Management Land Use Planning System. A permanent federal appropriation of $40 million has been authorized to support the undertaking.

APPENDIX A

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The pre-Columbian Hohokam Indians occupied the major river drainages of central Arizona and have been the subject of much intense archaeological research. Evidence indicates that the Hohokam began using river water for crop irrigation about 300 B.C. and modified and improved their irrigation systems over time until the maximum extent of these systems was achieved about 900 A.D. Two types of water control seem to have been utilized: 1) the direct exploitation of rivers through the use of irrigation canals, and 2) indirect use through controlled runoff within micro-drainages at higher elevations before it reached the rivers. At first, probably only those parcels of land with optimal soils and drainage were used, but apparently population increases fostered by agriculture itself, combined with increasing social and political complexity, necessitated more and more exploitation of marginal lands. Eventually, soil problems increased, imposing severe limitations on agriculture. These involved salt and alkali accumulation due to inadequate drainage, soil density and waterlogging. Additionally, the extension of cropping required the clearing of natural vegetation, which resulted in increased erosion and decreased available native food resources for periods when crops failed. The culture vanished completely about 1450 A.D., probably mainly because of their manner of river exploitation for irrigation. More recent archaeological studies are concentrating not only on river use but also on river abuse.

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Major droughts in the grassland region of the central U.S. have occurred rhythmically during the period of instrumental record. The time for the next one may be near. Early droughts disastrously reduced farm income through loss of crops and livestock. Since the 1930s they have accelerated contemporary basic changes in Americans within this region: fewer, bigger and more fragmented farms; public controls and subsidies; consolidation of urban business and services; and greater management. The next major drought will again accelerate long-term agricultural trends, but a sharp increase in urban federal assistance is likely, and revolutionary changes in settlement could be initiated.

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Desert Biology. Two volumes. Academic Press, New York, London. 1236 p.

The first volume deals with the biological aspects of the world's deserts. It focuses on the forces causing desert and arid regions, the evolution of desert plants, water economy, desert ecology and limnology, poisons, desert animals, and the adaptation and behavior of plants, reptiles, amphibia, birds, fish and mammals (including man). The second volume discusses hydrogeology of arid regions, desert soils, physical and vegetational aspects of the Sahara Desert, desert algae, lichens and fungi. A new approach to water relations of desert plants, desert anthropods and fishes, and man in arid lands (particularly the Pima Indians of the Sonoran Desert and the Mada in Salih Valley in the northwestern corner of Saudi Arabia).

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Irrigation has modified the environment of the central valley of Arizona for past 2500 years, beginning with the irrigation systems of the Hohokam Indians. Modification of the physical environment has included changes in climate, groundwater, surface water and vegetation. The social environment has been changed from a rural economy to an urban industrial economic system. Present and future problems related to irrigation in the area are discussed. Some of the problems are water demand, land subsidence, salinity, groundwater management and allocation of Colorado River water. Solutions to some of these problems are suggested.

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Two canyons in the Wasatch Mountains near Salt Lake City were compared: Red Butte Canyon had been protected from grazing for 40 years, while Emigration Canyon had been grazed heavily since settlement in 1847. Evidence points to the complete substitution of the original grass type in Emigration Canyon to one with unpalatable shrubs and Bromus tectorum, while Red Butte Canyon has maintained a rich plant cover including ten native grasses not found in Emigration Canyon. Sheet and gully erosion are prominent in Emigration Canyon.

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Livestock numbers in 19th century New Mexico and problems of gullying in the Southwest. Association of American Geographers, annals 57(4): 691-703. GA 69A-990.

In the 1880s intensive accelerated erosion began producing large gullies throughout the southwestern U.S. This modern arroyo cutting was originally attributed to deterioration of the protective vegetation cover because of below-normal rainfall and overgrazing by excessive numbers of livestock (4 million sheep in New Mexico in 1880). However, recent studies have stressed the greater importance of increased high intensity rainfall. Additional perspective is provided by an examination of livestock numbers in the upper Rio Grande region of New Mexico during the 19th century, particularly during the Mexican period when the ranges were heavily stocked with sheep (possibly 3 million head in the 1820s), but with little or no gullying. The incomplete record of livestock numbers in relation to climate and gullying backs up the climatic argument but also gives some new support to the older view that overgrazing was a major contributive factor causing severe modern gullying.

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An analysis of causes. Botanical Review 24(4): 193-252. (Reprinted as Arizona Agricultural Experiment Station Bulletin 299.)

Extensive portions of the desert grassland of southern Arizona, New Mexico and southwestern Texas have been invaded by woody species. Mesquite, creosote bush, cacti of the genus Opuntia, burroweed and snakeweed are among the principal invaders. The principal factors commonly believed to have caused this change are change of climate, grazing by domestic livestock, plant competition, rodents and fire. Of these various factors, change of climate seems to have had the least effect. Fires that were formerly frequent and widespread were the chief agency restricting shrub invasion. Since fires have been controlled, the introduction of domestic livestock, plant competition and rodents have been effective agents favoring woody plants at the expense of grasses.

Law, J.P., Jr./Witherow, J.L. eds. 1970
Water quality management problems in arid regions. U.S. Federal Water Quality Administration, Water Pollution Control Research Series 13030. 105 p. Available NTIS as PB-198 125. SWRA W71-06111.

A selection of papers presented at the AAAS committee on arid lands conference, Arid Lands in a Changing World, held in Tucson, Arizona, June 1969. Included are papers covering nitrate removal from agricultural wastewater, the effects of salinity standards on irrigated agriculture in the Colorado River Basin, problems of pollution of irrigation water in arid regions, salinity control in return flow from irrigated areas, natural pollution in arid land waters, distillation of wastewaters, animal waste runoff, water quality requirements, re-use of wastewater effluents, and water quality control problems in inland sinks.

Logan, Richard F. 1961
Post-Columbian developments in the arid regions of the United States of America. In L.D. Stamp, ed., A history of land use in arid regions. UNESCO, Paris. Arid Zone Research 17: 277-297.

A companion review to Armillas' on pre-Columbian America (q.v.), this paper describes the physical setting, including landforms, climate and vegetation. It offers a brief history of the development of a national land use policy: grazing industry, dry farming, irrigation agriculture, recreation and urbanization.

Love, R.M. 1970
The rangelands of the western U.S. Scientific American 222(2): 88-96. GA 71C-1155. SWRA W70-04907.

Cattle grazing is the primary use of the rangelands of the western United States. The western ranges fall into three distinct categories: northern Rocky Mountains, intermountain and Southwest. True grassland is rare in the Southwest. Instead, deserts and semideserts predominate. Vegetation management is the major problem in improving the rangelands. Brush conversion programs have shown substantial increases in water yield in the treated areas. This is due to the fact that an acre of brush uses six more acre-inches of water than does herbaceous vegetation. With proper management of brush in the watersheds of the West, the land can provide more meat and lumber, suffer less from erosion and flood, and be more usable for recreation. The rapidly growing need for more recreational land is causing conflicts with other land uses. The advantages of brush control and the use of controlled fires, transhumance, canopy architecture, leaf-area index and exotic grasses are other topics discussed.

McGinnies, W.G./Goldman, B.J./Paylore, Patricia 1968
Deserts of the world, an appraisal of research into their physical and biological environments. University of Arizona Press, Tucson. 788 p.

A book intended for those seriously interested in planning, managing and executing research or development efforts in the arid world. It contains evaluative comments on the work accomplished in weather and climate, geomorphology and surface hydrology, surface materials, vegetation, fauna and desert coastal zones. Extensive bibliographies for each section.

Morris, E.H. 1948
Modern overgrazing by livestock as the direct cause of ruin of southwestern agriculture, with a note by H.H. Chapman. Journal of Forestry 46(12): 929-931.

Reprint of a portion (p.5-8) of the author's 1939 Carnegie Institution of Washington publication, Archaeological Studies of the La Plata District, southwestern Colorado and northwestern New Mexico, dealing with conditions in the pueblo area before the advent of white man and the grazing of sheep and cattle. Overgrazing disturbed the equilibrium of a natural balance of forces such as rainfall, erosion and vegetation.

Paylore, Patricia, ed. 1976
Desertification: A world bibliography. University of Arizona, Tucson, Office of Arid Lands Studies. 644 p.

Compiled for the International Geographic Union's 23rd Congress, Moscow, 1976. Consists of 1,750 citations, most with abstracts. Produced from the OALS computerized Arid Lands Information System. Divided into regions covering the Sahara-Sahel, East Africa, South Africa, the Middle East, the USSR, Pakistan, India, China, Australia, and South and North America, with regional introductions by world experts. Maps.

Paylore, Patricia, ed. 1976
The Sonoroan Desert, a retrospective bibliography. Historical perspective, by W.G. McGinnies. University of Arizona, Tucson, Office of Arid Lands Studies, Arid Lands Abstracts 8. 777 refs.

Citations selected from the computerized Arid Lands Information System (ALIS) cover such diverse topics as environment, fauna, geomorphology, geography, surface materials, vegetation, desert grassland, succulents, water, weather and climate. Full abstracts for each with computerized keyword and author indexes.

Paylore, Patricia/Haney, Richard A., Jr., eds. 1976
Desertification: Process, problems, perspectives. Papers presented during a 14-week seminar series, November 1975-April 1976. University of Arizona, Tucson. 125 p.

The topic of this series was addressed by several generalists speaking on its ecology, trends, causes; followed by several case studies to illustrate the theses advanced generally. These dealt with areas in Australia, eastern Oregon and southwestern Arizona and northwestern Mexico.

Powell, J. W. 1962
Report on the lands of the arid region of the United States, with a more detailed account of the lands of Utah. Ed. by Wallace Stegner. Belknap Press of Harvard University Press, Cambridge, Massachusetts. 202 p.

A first-hand account of the arid region of the U.S. written in 1878. Subjects covered include physical characteristics of the region, the land system needed, rainfall of western U.S., water supply, questions relating to irrigable lands of Salt Lake drainage system, valley of Sevier River and that portion of Utah drained by Colorado River and tributaries. Author considers character of lands and engineering problems involved in their redemption and suggestions for the legislative action necessary.

Sears, P.B. 1959
Deserts on the march. 3rd ed., rev. University of Oklahoma Press, Norman. 178 p.

This popular account of man's misuse of the land and failure to understand its ecology centers around the historical development of land use in the United States. The cutting of forests, farming of cotton, plowing of prairies, polluting of rivers, overgrazing and general disregard for the welfare of the land are shown to be related to floods, mudslides, duststorms, erosion and natural calamities. The author argues that only through a broad ecological understanding of the environment and man's relationship to it coupled with moral commitment in the employment of technical resources and in our way of living will we be able to change our historic precedents.

Steward, George 1936
History of range use. In U.S. Senate Document 199, The western range, p. 119-133. Washington, D.C.

U.S. Bureau of Land Management 1968
The California desert. A recreation study of the desert public domain lands of California. Preliminary review U.S. National Park Service, Bureau of Land Management, Washington, D.C.

Woodbury, R.B. 1963
Indian adaptation of arid environments. In C. Hodge and P.C. Duisberg, eds., Aridity and Man. American Association for the Advancement of Science, Pu. 74: 55-85.

Briefly traces man's changing roles in the western U.S. Discusses food gathers, big game hunters, village farming life, villages and water sources, water control techniques, decline of village farming life, introduction of adaptable Athabascans, shift to wagework, collapse of Great Basin culture, rise and fall of the Sioux, adjustment to reservation life, Papago struggles in the desert, Indian adjustments and prospects. Climatic change in the 13th century was probably responsible for early decline of village farming life. Grazing abuses by Indians and whites have resulted in deteriorated rangelands. The plight of the Indian in the last century or so is not the result of environmental causes such as aridity; the causes are social. It can be seen as part of the worldwide problem of the non-literate, non-industrial world confronted by the technology and social and ethical systems of the western world. Indian techniques and their philosophy of working with the environment rather than against it may be indispensible ingredients for the successful utilization of arid lands.

APPENDIX B

A PARTIAL LIST OF U.S. AGENCY-SUPPORTED ACTIVITIES ASSOCIATED WITH DESERTIFICATION

I. U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)

A. Programs in the Sahel region include assistance to the Comite Permanent Interetats de Lutte contra la Secheresse dans le Sahel (CILSS) in planning its regional development program; establishing a water data collection and processing system for the Sahel Water Data Network; and developing national capabilities to control food crop pests throughout the Sahel.

B. Grants to institutions include one to the Florida Institute of Technology and another to the University of Arizona.

a. The Florida Institute of Technology is conducting a project entitled "Solar Cookers for Haiti: A Feasibility Study." Haiti's firewood and charcoal resources are becoming scarce as are those in other developing countries. The project consists of a review of solar cooker designs, evaluation of their compatibility with Haitian cooking requirements and preliminary design of a solar cooker appropriate to Haitian needs.

2. The University of Arizona was awarded a grant to strengthen its response capability in "Multiple Use Planning and Management of Natural Resources in Arid and Semiarid Developing Areas." The interdisciplinary faculty at the University of Arizona involved in the program is establishing linkages with institutions in developing arid and semiarid regions to promote service, training and research aimed at developing solutions to their problems.

C. USAID projects with specific countries are listed below.

1. Chad--The"Chad Range and Livestock Development" project will develop the manpower capability to implement a national range management program and, in the process, design a national range management plan. The project will include training in principles and practices of range management and a position on a national range and livestock planning commission.

2. Cameroon--The "North Cameroon Livestock and Agricultural Development" project involves regional development through resource management and will include a land use potentials inventory and development of range management practices, food crops and a livestock industry.

3. Ethiopia--A "Drought Rehabilitation and Development Strategy" project will guide government rehabilitation and development efforts in southern Ethiopia and will include aiding in the process of identifying proper donor assistance; studying and analyzing environmental, demographic and socioeconomic variables in Ethiopia; and formulating drought rehabilitation and development strategies for the southern lowlands.

4. Ghana--The "Developmental Applications of Science and Technology in Ghana" program administers a pilot research program on the problems of desertification in northeast Ghana which includes application of the experience and methods derived from the pilot study to two areas and an examination of mechanisms to establish research priorities.

5. Kenya--The "Survey of Semiarid and Marginal Lands" will include quantitative, narrative and graphic descriptions of the human and natural resources and existing infrastructure in the project area. Core problems that constrain development will be identified and delineated including population, migration patterns, erosion, desertification, water availability, deforestation, credit, production technology, marketing, extension, elements of agricultural education and institutional infrastructure along with the potential sociocultural constraints.

6. Mali--There are several projects with Malian institutions.

a. The "Land Use Capability Inventory" will provide guidance in national resource allocation through development of a 1: 200,000 map showing economic land classes and movement units and a tabular and narrative description of potentials and limitations of management units.

b. The "Mali Livestock Project" will test the vertical stratification of the livestock industry through range development, controlled grazing, post-season maintenance feeding, small-scale farm fattening and feedlot operations.

c. "Mali Livestock Sector Development" will initiate development of the Malian livestock sector through light development and management of the Dilly area (800,000 ha.), controlling the tsetse fly in a small area near Bamako, market development and training at all levels.

d. The "Mali Small Ruminant Survey" will determine the present position and appropriate place of sheep and goats in the Malian economy by surveying numbers, distribution, ownership and economic roles and by testing certain hypotheses of the role of sheep and goats in economic development.

e. The "Mali First Region Integrated Agricultural Production" project involves the western panhandle of Mali and should, with its successors, bring 13,800 sq. km. into ecological balance. Activities include a project allocation survey, developing a cropping system compatible with the environment and a program of grazing management.

f. The "Mali Operation Haute Vallee" will bring that portion of the Niger River bottom extending from just above Bamako to the Guinea border into ecologically balanced management through land-use condition and potentials survey, small-scale irrigation and village grazing and livestock programs.

7. Mauritania--Two projects in Mauritania are discussed below.

a. The "Mauritania 10th Region Development" program aims at optimizing ecological balance for economic endeavors, sustained livestock production and output and increased food supply in the region through a range and livestock management controlled demonstration, adaptive trials of soil and crop management, extension adoption of the new practices and grass fire control.

b. The "Mauritania Reforestation" project will improve the institutional condition of the national forest service and increase the supply of cooking fuel. Improved capability to manage the renewable resources of the public domain are likely to be emphasized as the project design proceeds.

8. Niger--The "Niger Range and Livestock Development" project will develop a pilot, controlled grazing program and a national grazing management system.

9. Senegal--There are two projects in Senegal.

a. The "Senegal Range and Livestock Project" is a pilot, integrated range management activity and will initiate a national resource management program through balanced grazing within defined boundaries, veterinary support, stock water development and salt, minerals and trace elements.

b. The "Senegal Land Conservation and Forestry" project will initiate a resource management program through the forest and wildlife program.

10. Upper Volta--The "Onchocerciasis-free Area Planning" project will develop an environmentally sound settlement plan for the "oncho-free" areas of Upper Volta and will include a land-use capabilities survey.

II. U.S. DEPARTMENT OF AGRICULTURE (USDA)

A. Wide-ranging research programs are discussed below.

1. Research directed toward classification procedures for range resources, formulating guidelines for predicting potentials and assessments of range responses to forage utilization regimes and vegetation manipulations alternatives is conducted at Tucson, Arizona.

2. Studies on the adaptation of plants to desert environments are conducted at the University of California, Riverside.

3. Methodology for the application of remote sensing to natural resources analyses is being developed at Tucson, Arizona.

B. Cold desert research programs are discussed below.

1. Research concerning ecology and management of salt desert shrub ranges is conducted at Provo, Utah.

2. Studies of shrub and tree improvement and culture for rehabilitation of wildlands is underway at Provo, Utah.

3. Investigations of ecology and management of pinon-juniper woodlands and associated shrub lands in the Great Basin are ongoing at Reno, Nevada.

C. Arid range research programs are discussed below.

1. Plants for arid range conditions are being selected at the Plant Materials Center, Los Lunas, New Mexico.

2. Mechanical treatment for establishing plants in arid ranges is being studied at the University of Arizona, Tucson.

3. Research aimed at selecting techniques and species for establishing range cover under arid conditions is being conducted at Tucson, Arizona at the Plant Materials Center.

D. Irrigated lands research includes a pilot project to determine ways to reduce best the saline drainage flows from irrigated lands into rivers, with return flow desalinization being the focus of this study at Wellton, Arizona.

E. Rehabilitation and Management Programs are discussed below.

1. Research directed toward developing methods for rehabilitating and managing mined spoils in the Southwest is conducted at Albuquerque, New Mexico.

2. Studies to promote reestablishment of plants, animals and hydrologic stability on surface mine spoils and water impoundments in the northern Great Plains are underway at Rapid City, South Dakota.

3. Investigations to develop methods for rehabilitating and managing mined spoils in the Intermountain and northern Rocky Mountains regions are ongoing at Logan, Utah.

III. ENVIRONMENTAL PROTECTION AGENCY (EPA)

A. Wide-ranging research activities are discussed below.

1. A cooperative research project with Egyptian institutions will assess the environmental and health consequences of the Aswan High Dam.

2. A desert biome study with the University of Alexandria (Egypt) utilizes modeling techniques to predict responses should certain events occur such as deforestation or reforestation.

3. Arid lands research projects are underway in portions of the western United States.

B. Specific animal and irrigated crop production environmental assessment projects are being conducted in both India and Pakistan.

1. Research is underway to develop management tools to dispose of animal wastes resulting from a production of animals and poultry in an environmentally safe manner.

2. Methods are being developed to control the quality of irrigation return flow along with investigating the bio-engineering aspects of agricultural drainage.

IV. U.S. GEOLOGICAL SURVEY (USGS)

A. LANDSAT research activities are outlined below.

1. General applications of LANDSAT imagery are discussed in the following sections.

a. Methods are being developed for terrain description and monitoring utilizing the Australian land systems research approach. Present experiments in Queensland, Australia will be continued in the western United States. The mapping system is an integrated system in which soils, vegetations and geomorphic features are combined into single mapping and land management units.

b. Methods of flood mapping with LANDSAT images are being researched which are particularly applicable to determination of flooded areas in arid and semiarid regions and which have potential for identifying recharge areas of both surface and deep aquifers.

c. A prime example of the use of LANDSAT images in desert regions on a worldwide basis is a project entitled "Sand Seas of the World," although it is not specifically an Earth Resources Orbiting Satellite project.

2. A regional LANDSAT program involves the impact of strip mining on range resources and wildlife habitat. The environmental impact analysis is using LANDSAT and aerial data in southeastern Idaho, but techniques and methods are transferable on a worldwide basis.

B. Two "Training in Remote Sensing Applications" courses for international students are given each year with the goal of teaching remote sensing data interpretative techniques. Other specific courses in various disciplines are given or requested. Courses can be tailored to address specifically land cover and other mapping of desert regions.

C. Two research programs focus on mineral wastes.

1. Stabilization of mineral wastes research aims to develop new or improved methods of stabilizing and/or reclaiming mined lands and mineral waste piles. Six field test sites which have either arid or semiarid climates are located in the states of Arizona, Colorado, Utah, Washington and Wyoming. Testing has been done on wastes from mining and/or processing copper, lead, zinc, uranium and asbestos.

2. Research on purification and conservation of mineral processing wastewaters seeks to develop effective methods of decontaminating metallurgical wastewaters for process reuse or for discharge. Recycling of process wastewaters is particularly important in regions having either arid or semiarid climates.

D. Several projects address arid and semiarid lands vegetation.

1. Studies of desert shrub ecology and utilization of soil moisture under high moisture stresses are being conducted.

2. Many aspects of the "Gila River Phreatophyte Project" have worldwide applications, especially the use of remote sensing in monitoring water use by vegetation and analysis of evapotranspiration.

3. An analysis of soil moisture data from sampling desert ecosystems to estimate evapotranspiration led to the discovery that the greatest reduction in available soil moisture was in desert grassland rather than oak woodland.

4. A study of saguaro populations in the Arizona desert is being conducted to determine causes for fluctuations in plant establishment. Climate, disease and man's activities are being investigated.

5. Abandoned agricultural land in the Tucson-Phoenix (Arizona) area is being studied to determine the rate of reestablishment of native vegetation species. The fields have been abandoned for about 40 years.

E. Hydrology research is also being conducted.

1. A study of grazing patterns aims to determine their effects on runoff and sediment yield in salt desert shrub terrain. The study site is in western Colorado.

2. The effects on arid lands hydrology of converting vegetation cover from woody shrubs to grassland are being investigated.

3. Another study involves assessing the effects of mechanical land treatments such as contour furrowing, pitting and ripping on hydrology including runoff, soil moisture availability and plant communities.

V. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

A. NOAA participates with the National Center for Atmospheric Research (NCAR) and the U.S. Air Force Environmental Technical Applications Center (ETAC) in extending the global inventory of existing climatic data.

1. Analyzed and observed data from the National Meteorological Center (NMC) flow into NOAA's National Climatological Center (NCC).

2. Similar data from the Air Force Global Weather Central go to ETAC and subsequently to NCC, where it becomes part of a common poll of global meteorological data. NCAR, using data from NCC and other sources, reformulates the data in ways convenient for research purposes, archives it and makes it available as a service to members of the research community. (A July 1975 NCAR report, "Data Sets for Meteorological Research," describes the types of data made available through the efforts of these three organizations.)

B. Long-range predictions and satellite programs within NOAA furnish a starting base for a climate diagnostic activity.

1. The National Weather Service (NWS/NMC) long-range prediction program includes necessary analyses with diagnostic studies as circumstances permit. Data sets are generated which extend back over the useful history of data used.

2. NMC ongoing programs include the study of year-to-year fluctuations in the stratospheric circulation, analyses of stratospheric warming and calculation of selected parameters related to the global stratospheric energy budget. Interrelationship between stratospheric and tropospheric circulations is explored.

3. NMC maintains a 30-day field of global weather data which, with similar data from the National Environmental Satellite Service (NESS), is the present source for compiling current climatic data sets.

4. NMC is compiling, for the Environmental Data Service Center for Climatic and Environmental Assessment (CCEA) and the NWS Agricultural Weather Service Office (AWSO), weekly extracts of the most elementary climatic parameters needed to assess current climatic and crop conditions over the world's major agricultural areas.

5. NWS AWSO, in cooperation with the U.S. Department of Agriculture (USDA), analyzes and publishes the previous week's weather and crop conditions in the U.S. A monthly summary for major foreign agricultural areas is included (although monthly climatic data from many areas are incomplete).

6. To the extent limited resources permit, CCEA is developing experimental crop yield models and is participating in the NASA/USDA/NOAA effort termed "Large Area Crop Inventory Experiment" (LACIE) to develop grain production forecasts. Current and potential applications include providing timely and early warning crop alerts, fresh water supply estimates and crop yields.

7. NESS prepares on an operational basis global charts of monthly and seasonal values of radiative heat budget and monthly and seasonal resultant wind fields at 200 and 700 millibars and their anomalies.

8. NESS is studying interrelations of cloudiness and circulation over large space and time scales.

9. NESS applies satellite imaging for detecting, measuring and mapping mean monthly winter snow cover over the Northern Hemisphere and is experimenting with snowfall prediction methods for North American and Eurasian winter months.

10. The Air Resources Laboratory (ARL) is examining variations in sunshine amount, total ozone and tropospheric temperature changes as part of a continuing investigation into climatic trends during the last few decades.

11. The Geophysical Fluid Dynamics Laboratory (GFDL) is investigating the sensitivity and stability of climate models to such external variables as the solar constant and atmospheric carbon dioxide to assess the value of using simple models in climate studies.

C. NOAA Experimental Research Laboratories conduct cloud seeding experiments in cumulus clouds over southern Florida for the purpose of inducing the merger and growth of cumulus towers developing in proximity to one another thereby increasing precipitation from the larger cloud system and hopefully increasing net precipitation over a large target area. The technique once proven may have a potential application in semiarid regions when appropriate clouds occur; although successful transfer of the massive or dynamic seeding approach used in Florida to drought areas is unlikely.

D. NOAA administers the World Weather Watch Voluntary Assistance Program for the Department of State. These funds:

1. Provide radio transmitting and receiving equipment to developing countries to improve national and international meteorological data exchange.

2. Provide wind-finding radar to tropical area countries.

3. Supply direct readout equipment to provide a capability for intercepting processed data from the GOES system.

4. Provide long-term and short-term fellowships to meteorologists in developing countries to increase their capability to use modern equipment and to improve their understanding of atmospheric processes that result in eventual, long-range weather and climate change.

5. Support international efforts under the Global Atmospheric Research Program (GARP) to define the research required to advance knowledge on the physical basis of climate and climatic fluctuations.

E. Understanding the physical basis of climate is the "second" objective of GARP. NOAA is contributing directly to GARP by:

1. Processing, analyzing and archiving atmospheric and oceanographic data.

2. Developing mathematical models and data management systems.

3. Specifying, developing and procuring special observing systems.

4. Conducting fundamental investigations of the dynamics of geophysical fluids, the atmosphere, the hydrosphere and the cryosphere over a wide range of time and space scales.

5. Expanding research efforts on cause-and-effect relationships between climate and atmospheric pollutants.

6. Conducting a comprehensive program to develop ground-based techniques for remote measurement of critical meteorological and oceanographic parameters.

F. NOAA input into the World Weather Watch (WWW) will impact on the United Nations Environment Program EARTHWATCH since the Global Environment Monitoring System (GEMS), the monitoring segment of EARTHWATCH, will make use of the observing, processing and telecommunicating systems of WWW.

VI. NATIONAL SCIENCE FOUNDATION (NSF)

A. "Analysis of Structure and Function of Desert Ecosystems" has as its goal elucidation of patterns and magnitude of accumulation and transfer of biologically important resources such as water, nutrients and energy; discovery and quantification of mechanisms by which those processes are limited or augmented; modeling the system conceptually and mathematically; and advancement of the base of ecosystem theory and aid in making management decisions about renewable natural resources.

B. "Structure, Function and Utilization of Grassland Ecosystems" will model the ecosystem; improve ecosystem theory; understand the biomass, trophic structure, water, nutrient and energy flow; and utilize and synthesize the results.

C. "African Climate During the Last Ice Age" is designed to test the hypothesis that East Africa was dry during the height of the the last temperate glaciation; examine the movement of the convergence zone between the dry Sahara Harmattan and cooler, moist air flows off the Gulf of Guinea; and understand the fundamental nature of global climate change using East African lake cores.

D. Research about "Aerosol Transport over the Equatorial North Atlantic Ocean as Related to Weather, Climate and Land Use in North Africa" will establish an aerosol and atmospheric turbidity network across the equatorial North Atlantic for monitoring the aerosol output of North Africa; identify source areas, determine if increased aerosol output is derived from normally arid and/or desert use practices; measure the time required for soils to become stabilized against wind erosion once rains return to normal; and measure mass transport of mineral aerosols to the ocean.

E. "Dynamics of Large-Scale Atmosphere and Oceanic Processes" research is a model study of the Sahelian region indicting that feedbacks from the ground creates weather patterns that reinforce and accentuate the arid or desert region.

Other NSF research includes "Formation of Deserts," "Midwestern Drought Indices and Drought Cycles Using Sea-Surface Temperature Anomalies from the Pacific," "Frequency and Power Spectral Analysis of Drought Cycles," "Arid Land Climate Patterns," "Southwestern U.S. Deserts and Their Similarity with African Weather and Climate," "Bovine Adaptation to Desert Environments Focusing on North Africa," "Adaptation of Large Mammals to the Sahara," "General Dynamics of Arid Land Ecosystems."

Also "Ways in Which Disparate Organisms Evolved in the Desert," "Management of Environmental Systems to Prevent Desertification," "Studies of Nomadism," "Relationship Between Drought and Grazing Patterns," "Ancient Social Adaptation," "Hunting and Gaming Practices in Botswana and the Kalahari," "Social and Biological Anthropology in the Kalahari," "Drought and Population Resettlement in the American Southwest," and "Bedouin Use of Surface Water, Grazing, etc., in Northern Arabia."

APPENDIX C

Spanish Summary

Introducción

La presente es para indicar el estado del problema de desertificación en los Estados Unidos. Se incluye un resumen histórico sobre los problemas del use de tierras en las zonas áridas y semi-áridas de los Estados Unidos, se discute algunos de los problemas actuales, y se delinea la necesidad de planeamiento y manejo racional de tierras en Norteamerica. La desertificación no es un problema solo para los países en desarollo. Es un problema qué el mundo entero tiene qué combatir. Norteamerica comparte en este problema, puede ofrecer soluciones, y sin duda beneficiará del intercambio de ideas y metodologías qué serán presentadas durante y despúes de la Conferencia de Desertificación de las Naciones Unidas.

Una sequía qué duro varios meses en la Reservación de los Indios Papago en Arizona ocasionó fondos y servicios de emergencia de varias agencias federales, y causó severas perdidas de ganado y cultivos. Los programas de reclamación de tierras y la asistencia a las reservaciones Indias han alcanzado a los billones de dolares--y tanto los beneficios como los gastos tienen ramificaciones nacionales. Con la posible excepción de algunos de los usos de recreación, se deberá acentuar qué la experiencia nortecamericana sobre la desertificación será pertinente y aplicable a otras zonas áridas y semi-áridas del mundo.

Historia

Se han utilizado las tierras áridas y semi-áridas en Norteamerica durante los últimos 11,000 años, y quizás mas, con el cultivo ocurriendo hace 6,000 años. Hasta el siglo XIX, la tenencia de tierra fué el problema principal en Norteamerica. Acción por parte del Congreso de los Estados Unidos trató de establecer controles sobre pastoreo, pero hasta hoy día el control científico del pasturaje se complica par el uso multiple y las numerosas acciones legales referentes a la propiedad y arrendamiento de tierras.

Pasturaje

La mayoría de los especialistas sobre el control científico del pasturaje están de acuerdo que´ muchas tierras publicas (federales) y privadas se están degradando, y qué se deberían aumentar los controles. Hay muchos casos bien documentados en los Estados Unidos en los cuales el sobre-pastoreo causó la invasión de arbustos pequeños de poco valor nutritivo, la aceleración del proceso de erosión, y el agotamiento de aguas subterraneas.

Agricultura de Riego

El riego ha transformado literalmente muchas partes de los desiertos del suroeste árido de los Estados Unidos en centros de producción agricola. Pero el riego ha contribuido al proceso de desertificación debido al consumo de agua, salinización del suelo, y a veces el abandonamiento de estas tierras agricolas y su conversación a tierras estériles sin utilidad.

Minería

Aunque sus efectos no son extensivos en area, la minería puede practicamente crear un desierto local.

Urbanización

La urbanización puede ser uno de los mejores usos para las tierras áridas y semi-áridas, con tal de que´ el buen manejo y el sentido común se use en cada caso. Aunque el mal uso de aguas urbanas podría resultar en "ciudades fantasmas" y desiertos de concreto, los problemas qué mas se comentan son causados por los comerciantes de tierras, quienes subdividen el desierto, construyen "calles," y tratan de vender terrenos áridos a personas crédulas. Centenares de estas "calles" sin pavimiento cruzan los desiertos de Arizona, Nueva Mexico, y Nevada, sin ningún edificio visible, y se convierten en arroyos, los cuales destruyen las capas superficiales del suelo.

Recreación

Debido al sol en las regiones áridas, el buen ingreso del trabajador americano, y mas tiempo para el recreo, se ha creado un problema de degradación de tierras tanto fastidioso como interesante. Motocicletas, jips de cuatro-tracción, y otros vehículos de recreo han invadido el desierto y han dejado sus marcas.

Freatofitas y Otros Controles de Vegetación

Muchos de los arboles qué se encuentran al borde de los ríos y arroyos, y qué consumen mucho agua, las freatofitas, debrían, en la opinion de algunos, ser eliminados en ciertos lugares. También se ha sugerido la eliminación de vegetación de millones de acres de bosque y desierto en Arizona, para incrementar el drenaje de aguas. Tales planes, sinembargo, podrían tener consequencias serias al largo plazo en cuanto al potencial de desertificación. Al corto plazo, incrementando el drenaje de agua por medio de la eliminación de vegetación representará menos agua infiltrandose a las aguas subterraneas, y sedimento se accumulará mas rapidamente en las cuencas de captación.

Resumen

Aunque la palabra "desertificación" es relativemente nueva en el vocabulario científico inglés, el mal uso de la tierra y los recursos naturales no es nuevo. La desertificación es realmente un problema serio; entre otros, los factores contribuyentes son: sobre-pastoreo, salinización de los suelos, agotamiento de recursos de agua, presiones de población, abandonamiento de tierras, algunas actividades mineras, y la destrucción de la superficie del desierto por vehículos de recreo.

Sería un error ignorar las consequencias de la desertificación en los Estados Unidos. Mientras que la alta tecnología americana tiene gran capacidad de producción, tiene igualmente gran capacidad de destrucción. Si los planificadores y administradores de recursos naturales, los intereses privados, y las agencias federales de regulación no mantienen vigilancia sobre la degradación de tierras en el suroeste, la desertificación podría llegar a tener repercusiones nacionales de serias proporciones. Tenemos el conocimiento técnico para controlar, y en ciertos casos, hasta reversar la degradación de tierras. Sinembargo, las presiones de una población que está creciendo demasiado rápido, como en muchos otros países, junto con los problemas sociales relaciondandos con la aplicación de la tecnología conocida, no permiten un optimismo sin cautela.

DESERTIFICATION IN LATIN AMERICA FROM AN ECOLOGICAL AND AGRICULTURAL VIEWPOINT

Fernando Suárez de Castro

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DESERTIFICATION IN LATIN AMERICA FROM AN ECOLOGICAL AND AGRICULTURAL VIEWPOINT

by Fernando Suárez de Castro *

A. GENERAL CONSIDERATIONS

1. It might be as well, before entering into a discussion of this subject, to attempt to define the meaning of some terms connected with it so as to ensure that wherever they are used the same phenomenon or situation is being described. Only with clearly defined terminology is it possible to avoid confusion which gives rise to misunderstandings, divergences and even conflicts, or even more serious, to apparent agreement which conceals marked differences in the understanding and evaluation of the situations described.

2. The first term that must be defined is the recently coined word desertification. We understand that it is intended to identify the process of degradation of arid or semi-arid zones, which culminates in the transformation of such zones into unproductive deserts. Desertification would therefore be a form of deterioration of a specific ecosystem, taking place over fairly long periods and for different reasons, which we shall try to give later in this study. The term is intended to have a geographic scope reaching only to the borders of the zones with scarce rainfall, which excludes the extensive humid regions, or areas with sufficient rainfall for the continuous production of agricultural crops.

3. The discussion of desertification thus deliberately omits the problem of the deterioration of large areas situated outside the arid zones, as a result of the improper use of agricultural land which

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The author would like to express his gratitude for the co-operation of Dr. Peter Duisberg, who reviewed the study and contributed some interesting suggestions.

/causes or

causes or favours water erosion or the destruction of the soil's productive potential by rain.

4. In Latin America, this deterioration of humid regions is of great significance since it affects extensive and densely populated areas and threatens territories with a vast productive potential. We refer, in the first case, to regions such as those located within the boundaries of Haiti, and in the second case to areas of such importance for the future of the continent as the Amazon region. Therefore, the desertification referred to in this study does not cover the complete range of phenomena causing the destruction of land in Latin America, but is confined to arid and semi-arid regions, which present very special features and require treatment accordingly.

5. The terms extremely arid, arid, and semi-arid are used to designate regions in which rainfall is either non-existent or very scarce, so that ecosystems develop with special characteristics. Under such conditions, agricultural and livestock activities range from "impossible" to "very difficult and limited" or merely "difficult and requiring special care". Rainfall, when it occurs in arid zones, is infrequent and irregular; it covers small areas and is often very heavy, so that not infrequently almost the whole of the annual rainfall occurs in the form of one or two showers.

6. Several indexes have been developed for the classification of climates, and these can be used to establish the climatic characteristics of arid zones. Among them may be mentioned Martone's equation which relates rainfall with temperature, and Thornthwaite's index which relates rainfall with potential evapotranspiration (or the evaporation from a surface completely covered with vegetation, when there is moisture permanently available), taking into account the length of the day and the temperature.1/ Professor Meigs was commissioned by UNESCO

1/ It is worth noting that there is much discussion regarding the accuracy or usefulness of the various indexes developed for the climatological classification of geographical regions. From a practical point of view, however, the predominating factor for distinguishing deserts (or extremely arid zones) arid zones and semi-arid zones, all other factors being equal, should be the extent to which they can be used by man according to the climatic conditions, especially those related to the availability of water for plants and animals.

to work on this basis on the preparation of a map showing the distribution of arid land in the world, from which the map of Latin America included here (with some modifications) has been extracted.

7. Needless to say, although the essential characteristic factor of arid zones is the small quantity and irregularity of the rainfall, there are many other factors involved such as temperature, insolation, relative humidity, evaporation, vegetation, and composition of the soil.2/

8. With the purpose of differentiating zones with varying degrees of aridity on an ecological and agricultural basis, it might be said that, according to the criteria applied in Argentina,3/ for extensive or common agriculture to be successful in a semi-arid region it would have to be practised with the aid of special techniques for the storage, conservation and use of rain-water; arid regions, for their part, receive so little rain that even if dry farming techniques are used there is not enough precipitation to cover the needs of such common crops as cereals and cotton,2/ while in extremely arid regions there is insufficient rainfall for the needs of any kind of natural vegetation except, in some cases, a few widely-scattered specialized plants, such regions often suffering from a complete lack of rainfall for continuous periods of as much as 12 months.2/ 4/ Some authors add that a feature of these desert zones

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2/ A sound discussion of the hydrometereological factors used in the classification of arid zones may be found in the study by C.C. Walter, "Climatologyand hydrometeorology with special regard to the arid lands" in The problems of the arid zones. Proceedings of the Paris Symposium. UNESCO, 1962.

3/ For a full description of arid and semi-arid land in Argentina, the report presented by the delegation of that country at the Latin American Conference for the Study of Arid Regions, held at Buenos Aires in 1963, may be consulted. (Comité Argentino para el Estudio de las Regiones Aridas y Semiáridas. Las tierras áridas y semi-áridas de la República Argentina, Informe Nacional, Buenos Aires, 1963, 54 pages.)

4/ E.S. Hills, Ed. Arid lands. A geographical appraisal. Methuen and Co. and UNESCO, London, 1969, 461 pages.

/is that

is that it has never been possible to use them for permanent pasture, even after the surrounding areas have been occupied for over 50 years, which is a clear sign of their absolute inhospitability even for the most extensive and meagre agricultural use.

B. ARID AND SEMI-ARID ZONES OF LATIN AMERICA

9. These data can be used to characterize the dry, arid or semi-arid regions of Latin America, the distribution of which is shown in the attached map prepared by Professor Meigs for UNESCO. It will be seen that these regions are located for the most part in Argentina, Chile, Brazil, Peru, Venezuela and Mexico.

10. In Argentina it is estimated that the semi-arid region covers an area of 41 million hectares (or 15 per cent of the whole area of the country), while the arid region covers 170 million hectares, or 60 per cent of the whole territory, so that more than 75 per cent of the continental area of Argentina is affected by "arid conditions" (see footnote 3). The semi-arid region is divided into two sub-regions: the Pampa and the Chaco; and the arid region includes five sub-regions: the Chaco, pre-puno, Andean puno, monte and Patagonia (see footnote 3). The economic importance of the semi-arid region of Argentina may be gauged not only from the extensive area it covers, but also from the existence in it of over 10 million head of cattle, over 5 million hectares sown to cereals and industrial crops and a similar area sown to forage crops.

In the arid region, it is worth noting that there are over 3 million head of cattle and about 20 million sheep (see footnote 3).

11. Over half the territory of Chile may be considered extremely arid, arid or semi-arid. This huge region includes the Norte Grande, wwith the provinces of Tarapacá and Antofagasta in which the Atacama Desert is situated; the Norte Chico, with the provinces of Atacama and Coquimbo; and the Central Zone (semi-arid). There is important mining activity, especially in the north, while the Central Zone is the heart of the country, because of the concentration of population there and its agricultural and industrial production.

/12. In

12. In Peru the arid zone comprises a narrow coastal strip which extends the length of the Pacific coast; although it receives less rainfall than the Sahara, it is the centre of the country's economic and cultural life, since the rivers that rise in the Andean foothills and flow into the Pacific have created some 50 oases which constitute as many rich centres of irrigated agriculture. In the highlands, the semi-arid Altiplano with its extensive plains of natural grasses of low subsistence capacity provides sustenance for a sizable population of animals of the Camelidae family and sheep which, together with mining, constitute the main wealth of this depressed region populated mainly by the original Indian inhabitants and extending up to Bolivia, where it is the most densely populated area of the country.

13. In Brazil, the arid and semi-arid areas are found in the north-east, whose worst feature is the exceedingly irregular rainfall which causes severe droughts in the region; the problems of poverty due to over-population and the aridity of the soil are very serious and, although large-scale irrigation projects have been carried out in this region over the past 40 years and there has been mass migration to more humid areas, the basic ecological and social problems have not yet been completely solved.

14. In Venezuela the dry zones comprise Guajira (the dry zone also extends to that part of Guajira which is in Colombia), the land in the northern part of the Maracaibo depression, the west coast of Falcón, the Paraguaná Peninsula, the Barquisimeto highlands, the lands bordering on the Gulf of Cariaco, and various parts of Margarita Island.6/ 7/

15. In Mexico, about 57 million hectares inhabited by approximately 8 million persons are classified as arid; this huge territory covers part of the States of Baja California, Sonora, Chihuahua, Coahuila,

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6/ An excellent study which was widely consulted in preparing this article is that by A.L. Cabrera, "Latin America" in UNESCO, Plant ecology. Review of research, Paris, 1955, pp. 77-113. The attached bibliography includes 284 publications which represent a very wide collection of studies on this subject published up to 1955.

7/ Marco Aurelio Vila, Las sequías en Venezuela. Fondo Editorial Común, S.C., Caracas, 1975, 176 pages.

/Durango, Zacatecas,

Durango, Zacatecas, San Luis Potosí, Nuevo León, Tamaulipas, Querétaro, Hidalgo, Puebla, Oaxaca, and Territorio de Baja California. The semi-arid zones cover about 24 million hectares, mostly bordering on the arid zone.8/

16. Owing to the lack of moisture and consequent absence of vegetation in the arid zones, the soil is generally undeveloped, the degree of immaturity being such that it frequently consists of simple accumulations of partially decomposed rock material. There is no vegetable mould and there may be quite a high accumulation of minerals that are not dissolved in water and so cannot be assimilated by the plants. The organic material content of the surface horizon is generally less than 1 per cent, and the neighbouring horizons show calcium accumulations which may become consolidated in the form of saline crusts. This type of soil tends to accumulate sodium salts if there is contact with water and poor drainage, and it is commonly found to contain materials that are carried by the wind and deposited on the surface (see footnotes 3, 6 and 8). Sometimes the removal by erosion of the surface horizon, which consists of a very few centemetres of useful soil, uncovers a deserty-type paving with a great quantity of pebbles and ruts which show the brilliant burnished surface of the desert (see footnote 3). It may be added that since no mineral elements are lost through leaching, the soil in arid zones is often rich in minerals and capable of producing abundant crops when irrigated.

17. The vegetation has been studied in the various phytogeographical regions, domains, and provinces. Some studies which may usefully be consulted are those by MacDougal and his colleagues of the Carnegie

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8/ For a description of the arid and semi-arid zones of Mexico, see Comité Mexicano de Zonas Aridas, Informe Nacional, México. Conferencia Latinoamericana para el Estudio de las Regiones Aridas. Mexico City, 1963, 52 pages. On the utilization of these areas, it is worthwhile consulting the following study: M. Lorenzo Martínez and L.J. Maldonado, Importancia de las zonas áridas en el desarrollo general del país. Productora Nacional de Semillas, Mexico City, 1973, 29 pages.

/Institute in

Institute in Washington, D.C.; Nelson, Mueller and Johnston of Harvard University; X. Hernández, etc. for Mexico; Svenson, Williams, etc. for the coastal strip on the Pacific extending from Peru to Chile; while Pitier and Williams have made a study of the vegetation on the arid coast of Venezuela and Sampaio, Nobrona, Smith, etc. have described the vegetation of the arid zones in the north-east of Brazil (see footnote 6).

18. According to several authors (although the nomenclature they give of phytogeographical territories varies somewhat) it may be accepted that a functional classification of the arid zones of Latin America would be to consider them as lying in the neo-tropical phytogeographical region, with five domains (the Caribbean, the Brazilian extra-Amazon domain, the Pacific coast, the Chaco and the Andean domain) and a varying number of "phytogeographical provinces" within each.9/

19. It is not the intention in this schematic outline, however, to go more deeply into such specialized analyses as those presented in many scientific studies, among which mention may be made of several prepared by UNESCO in its ambitious programme of studies on arid zones carried out actively since 1950.10/ 11/

9/ In the important study comprising a bibliographical review and synthesis referred to in footnote 6, a schematic description is given of the various phytogeographical domains, from Mexico in the north to Argentina in the southern cone of South America.

10/ In order to enlarge on these concepts expressed here in broad outline, it is worth consulting the UNESCO reports of the Programme Series on Man and the Biosphere (MAB), particularly the Final Report of the Panel of Experts on Project 3: Impact of human activities and land use practices on pastureland: savannas, pastures (from temperate to arid areas), tundra. This Panel met at Montpellier, France, from 2 to 7 October 1972.

11/ Conferencia Latinoamericana para el Estudio de las Regiones Aridas. Comunicaciones y resúmenes de trabajo. Buenos Aires, 1963. This includes the summaries of over 150 studies presented at the Conference. These studies, most of them by Argentine authors (although there are also valuable contributions from Chilean and Mexican specialists), cover a wide range of subjects connected with the evaluation of available resources and their utilization in arid zones.

/20. For

20. For the purposes of this study, suffice it to say that in the arid zones of Latin America there are various natural communities of low forest species which grow in the rainy season, among which grasses predominate (such as some species of the Agrostis, Eragrostis, Panicum, Paspalum, Festuca, Setaria and Bronus genera); in some cases there are also leguminous bushes (Cassia, Prosopis) and succulent plants (Cactaceae) all of which are of some value for animal feed and in a few cases for industrial use. The fact that the annual plants used as forage dry up and die if the dry season is prolonged, and that there are many species of plants and bushes which are of little or no value as forage, greatly reduces the "subsistence capacity" of arid zones, the maximum use to which they could be put, under natural conditions, being no doubt for extensive grazing, combined in a few cases with the exploitation of plants of some commercial value (Prosopis, Opuntia, Parthenium, Agave, etc). Some indigenous tribes which still exist and other which have been exterminated by the white man subsisted or subsist at very low levels of living by exploiting several of these products of commercial value (Candelilla, Guayule, Sisal, etc.). It should also be noted that the arid and semi-arid zones of the continent have generally been utilized on the basis of permanent occupation and that nomadism is not a common practice.

C. DEGRADATION OF ECOSYSTEMS

21. The growth of vegetation as a result of rainfall gives the false impression during a short period of the year that the land in arid zones may have a greater subsistence or productive capacity than it actually has, resulting in too many animals being put on the land. As the drought continues these animals have less and less forage and, consequently, the vegetation is destroyed by over-grazing. A similar but even more serious situation arises in years with more than average rainfall, which are frequently followed by several years of severe drought. If to this is added the effect of being

/extensively trodden

extensively trodden by cattle, which hardens the surface layers of the soil and hampers the renewal of the plant cover, it is easy to assess the cumulative effect of the exploitation of arid zones by over-grazing. The soil, denuded of all vegetation, is then an easy victim first of wind erosion, and later of water erosion with the rains, and a cumulative process of degradation is set in motion which culminates in the desertification of the affected area.

22. Wind erosion, especially the "suspension" type which removes and carries the lighter particles of the soil, often over considerable distances, in a direction parallel to the air currents, is very frequent in the arid zones and its effects are particularly harmful as it carries precisely the most valuable part of the soil, which is that formed by the lighter particles.12/

23. An extreme case of ecological deterioration caused by wind is the massive drifting of sand in the form of dunes or loose deposits which invade agriculturally usable land and literally convert it into desert by covering it with thick layers of fine sand which inexorably follow their course in the direction of the prevailing winds. This phenomenon is significant in the arid zone of Argentina and the Pacific coast strip of Peru and Chile, and in many arid areas of Latin America the stabilization of the dunes is one of the most urgent needs in the fight against desertification. The process of the deterioration of arid and semi-arid pastureland already described is shown schematically in figure 1, adapted from a UNESCO publication (see footnote 10).

24. Another serious form of deterioration is that caused by ploughing and the sowing of crops which require weeding in arid areas, taking advantage of the short period of humidity produced by the sporadic and irregular rainfall. Misled by the possibility of cultivating annual food crops, populations which live at subsistence

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12/ Suárez de Castro, Fernando. Conservación de suelos. Colección Agrícola Salvat. Salvat Editores, S.A., 2nd edition, Barcelona, 1965, 319 pages.

/level, in

level, in virtually arid areas generally located on the limits between arid and semi-arid regions plough and sow this type of land. The torrential downpours which are the characteristic of rainfall in very arid areas then hit soil which is bare and cleared and thus in a state of extreme vulnerability for the waters to wash away the upper layers, causing damage which in some cases is irreversible and contributing to the deterioration of the fragile ecological system of the type of area concerned and the consequent merciless advance of the desert (see footnote 12).

25. Among the effects deriving from desertification which can be termed reversible, but nevertheless serious, mention may be made of the loss of livestock through lack of fodder, which is an intermediate link in the chain of events beginning with the poor use of land and ending with the deterioration of the economic situation, health and general standard of living of the population affected. Even the death of human beings through starvation, especially children and old people, is not unknown in some arid areas of the continent where the process of ecological deterioration has reached its greatest extremes.

26. The tree cover of the arid areas generally consists of high thickets or slow-growing drought-resistant arboreal plants which in many cases form patches within areas covered by herbaceous vegetation and in others constitute vegetal areas of varying extent which are sometimes developed commercially (for example, thickets of izote and mesquite). These have suffered continuous and intense destruction because they are used for firewood in the homes of the families which inhabit the region or for raw material to make charcoal; because of excessive grazing (especially when the herbaceous cover has been dried out by prolonged drought and goats have been reared)

/which causes

which causes the progressive weakening and death of the trees; because of the burning of pastureland, a practice which is widely used on a periodic basis as a means of destroying weeds and encouraging the reemergence of natural pastureland and which, while advantageous in that respect, in many cases destroys the trees; and, lastly, because of direct cutting in order to extend pastureland or sow fresh crops, especially in the short periods of rainfall and above all in the years when the rainfall is more abundant. In such cases the destruction of the forests through the generally combined action of these factors represents a serious damage to the ecological system, since it destroys the tree cover and breaks a delicate balance, thus unleashing the multiple action of high temperatures and the active agents of erosion.

27. In their natural state, semi-arid areas can be more intensely utilized since the conditions of drought are not so extreme. The supportive capacity of the land is greater, so that it is possible to cultivate forests of economic value by choosing the species with care and to rear livestock permanently with a much higher density per unit of area than that possible in the arid stretches. Harvests of annual crops can be produced with precautions which could be termed of medium intensiveness related to the prolongation of the period during which the vegetation can utilize the available quantities of water. In some countries a large proportion of the most productive agriculture is found in this area: Argentina, for example, produces over 40 per cent of all its cereals and forage crops in the semi-arid Pampa subregion and about 50 per cent of the total area of cotton is sown in the semi-arid Chaco subregion (see footnote 3). This ecosystem is also very fragile, however, and needs careful management to protect it from water and wind erosion.

/D. UTILIZATION

D. UTILIZATION AND MANAGEMENT OF ARID AND SEMI-ARID AREAS

28. As may be gathered from the foregoing, there are three objectives which should be sought in designing systems for the utilization and control of arid and semi-arid areas. In the first place, vigorous action to protect the existing production capacity is essential; secondly, there is a need for careful work to increase that production capacity in order to seek a higher stable ratio (or perhaps a better dynamic balance) between the available resources and the society which lives from them, at a much higher or more intensive level of utilization than the natural level; thirdly, it is important to design systems of land management in keeping with this level or dynamic balance which will make possible the intensive and permanent use of the resources without decreasing or damaging them.

29. Since water is the main limiting factor in the utilization of arid areas, it is not surprising that in the search for a much higher and more intensive level of utilization than the natural level the task of providing this element in order to complement the quantities which are supplied by the scarce and sporadic rainfall has had very high priority since the most distant times. Irrigation is the system which has been most used in the past, and will assuredly continue to be used, to increase the production potential of the arid and semi-arid areas.

When man became sedentary he began to carry out works designed to capture available or excess quantities of water at one point and convey it to an arid area for application to the soil so as to provide for the needs of the vegetables he wished to cultivate and produce. Run-off, which during the rainy months originates in the arid regions themselves (and can constitute high volumes since, as has already been pointed out, the rainfall in arid areas is intense and largely falls during the periods of a few days or weeks); ground water originating from the vertical and lateral movements of this element under the surface of the land, and the deposits or currents existing in areas some distance from the place where the water is to be used are all sources which can be used to irrigate land, although obviously the use of each of the three

/sources mentioned

sources mentioned requires a different mechanism and gives rise to very different ecological problems. It could however be said that in general the supply of irrigation water is costly and that in more cases than one justifiable resources of capital, technology and labour (which are scarce in the region) have been invested in constructions which have often subsequently operated at a much lower level of efficiency than that for which they were designed, while in other cases serious ecological problems have originated in adjoining areas, or even in the areas which were to be assisted, and this has sometimes led to the abandonment of the work with heavy economic and social costs, the utilization of the system at a very low level of efficiency, or serious deterioration in some areas as a result of erosion, salination, the fall of the phreatic level, etc. It has also been found that in many of the current irrigation systems in Latin America only a fairly small percentage (as little as 30 per cent) of the water captured reaches the irrigable land because of losses by evaporation and seepage which could be avoided; furthermore, a large amount of the remaining water is then lost because of inadequate application to the land. It is therefore easy to see the need to study all the effects which irrigation has or may have in particular regions until they are fully understood; this provides a basis for seeking the most appropriate ways of using this important method of improving arid areas, while avoiding as far as possible any danger of provoking serious deterioration which could represent a major contribution to desertification and ensuring the most efficient utilization of the available water.13/

13/ The impact of irrigation on various constituent elements of the ecosystems of arid and semi-arid areas and possible topics for research in this field are presented in the "Final Report of the Export Panel on Project 4: Impact of human activities on the dynamics of arid and semi-arid zone ecosystems, with particular attention to the effects of irrigation", UNESCO, 1976.

E. INTEGRAL RESEARCH

30. The three objectives mentioned in paragraph 28 as parameters for the design of systems for dryland utilization and management (in two of which irrigation has a predominant influence) must be sought on the basis of integral fundamental research, on the one hand, and integral adaptative and applied research on the other. This does not mean that extensive research has not already been carried out on the most varied aspects of the situation and utilization of arid and semi-arid areas. On the contrary, the research projects carried out are literally innumerable (see footnotes 6 and 11). The application of the knowledge gained and the innovations developed, however, has been carried out at a very local level, in very partial terms, and there is no sign that the valuable new knowledge which is being accumulated in each sphere has been applied in a broad, organic and integral way.

31. It is obvious that the central aim of the research, in its first stages, is and must continue to be on the one hand, that of discovering the components of the ecosystems, including factors related to the people who inhabit the area, the social structure within which it has been organized and the economic motivations of that society, and on the other, that of understanding the interrelations between those components, so as to have firm bases for determining what measures can be taken for the rational and long-term utilization of natural resources. The part which could be termed "taking stock" includes study of the situation and current use of the resources involved: vegetable, animal, the human population and its socio-cultural environment, and it also includes a look into the past so as to try and explain, through an analysis of the geographical-ecological and historical background, how and why the current situation has arisen, and consideration of the aspirations of the population as regards the use of resources. All this integrated material, after clarification of the functional relations between the components, makes possible a joint evaluation of the ecological and technological potential of the system and an assessment of the gap

/which separates

which separates the current and potential situations. Finally, action is taken to fill this gap and proceed to a new dynamic level of interrelation between the population and its needs on the one hand, and the available resources on the other (see footnote 10).

32. This simple explanation of such ambitious projects naturally ignores the complexities which have to be faced in each phase, but it has the advantage of schematically outlining the main features of some of the programmes already in operation and others which it will be necessary to initiate. On reaching this point, it is necessary to select alternatives which are not only viable but are also the most suitable from the economic, ecological and social point of view to provide for the growing needs of the population, and these alternatives must be channelled into control programmes covering specific goals and objectives, means of attaining them, and the logistic labour, finance and institutional resources available for attaining the objectives.

33. It should perhaps be stressed that the studies carried out must have physical, biological, economic and social dimensions, which means that instead of carrying out isolated studies in these spheres and then linking them, studies must be planned in an integral way, linking together the set of circumstances of the four categories mentioned which typify each problem or situation and thus studying them as indivisible wholes with individual characteristics different from those of each of the components.

34. The application of this criterion inevitably leads to the selection of a methodology of "systems analysis and development of models", which makes it necessary to formalize the relations between the components of the ecosystem (through mathematical equations and logical analyses) in the construction of a functional model which is tested

/against real

against real situations until it is validated and can then be applied. All this is part of a (stochastic) process of successive approximations to reality.14/

F. CO-ORDINATION MACHINERY

35. With an approach of this nature, the bases are created for ensuring broader utilization than at present of research resources, since it has already been pointed out that one of the serious current problems is the very limited use made of locally-discovered innovations, even in cases where there could be broad application of them. The systems approach and the establishment of machinery for the co-ordination of work and the exchange, assembly and dissemination of information on arid areas of the continental level would also be very beneficial for Latin America. The establishment of a (Latin American) regional center for the integral protection and development of arid areas (including not only agricultural aspects but also the industrial sector and the exploitation of non-renewable natural resources), supported by international bodies and working in close co-operation with national institutions, within an approach based on systems and models, would be a good way of channelling towards the region technological innovations and knowledge developed and accumulated in other latitudes, while at the same time taking advantage of the experience and professional expertise of foreign scientists and technicians of recognized authority in problems of the arid regions.

14/ With regard to production systems it is useful to consult the work submitted at the International Seminar on Research into Production Systems in Agriculture, held from 28 September to 3 October 1975 in Brasilia, under the auspices of the Emprêsa Brasileira de Pesquisas Agrícolas (EMBRAPA) and the Instituto Interamericano de Ciencias Agrícolas (IICA). The papers presented by John L. Dillon "Guidelines systems research priorities", J.R. Anderson "Implications of risk for systems research" and H.A. Nix "Models of crop production systems and their usefulness" are of particular interest.

/The same

The same could be said of the establishment of documentation and information machinery which would be closely connected with the Regional Centre mentioned and could take advantage of the network of the AGRIS and AGRINTER systems:15/ such machinery would deal primarily with the collection, processing and dissemination of the relevant information as it appears. It would also not be difficult, and very useful to envisage the operation of a training programme for Latin American technicians and scientists working in arid areas, on the basis of the activities of the Regional Centre and the information and documentation programme. Thus common conceptual bases and procedures would be created in all the countries with arid regions, while at the same time raising the level of training of the national technical teams and providing effective co-ordination at the continental level.

36. As an initial step to implement the above suggestions it might be worth taking advantage of the time remaining before the Nairobi meeting to make a situation study at the regional level and evaluate as a whole the many research projects carried out in recent years in Latin America on various aspects connected with the definition and management of the ecological complex included in the dry regions of the continent. On this basis, and with the assistance of the national technicians who work in these regions, a proposal enjoying the approval of the countries involved could be worked out for consideration at the Nairobi meeting.

15/ On the subject of the organization and operation of AGRIS (International Information System for Agricultural Sciences and Technology) and AGRINTER (Sistema Interamericano de Información para las Ciencias Agrícolas) mention may be made of the following papers: IICA. Sistema Interamericano de Información para las Ciencias Agrícolas-AGRINTER: Bases para su establecimiento, Turrialba, Costa Rica, IICA-CIRA, 1973, 18 pp. and Malugani, M.D., AGRINTER. The Latin American and Caribbean information network: a contribution to the AGRIS level one. San José, Costa Rica, IICA-CIDIA, 1976, 16 pp.

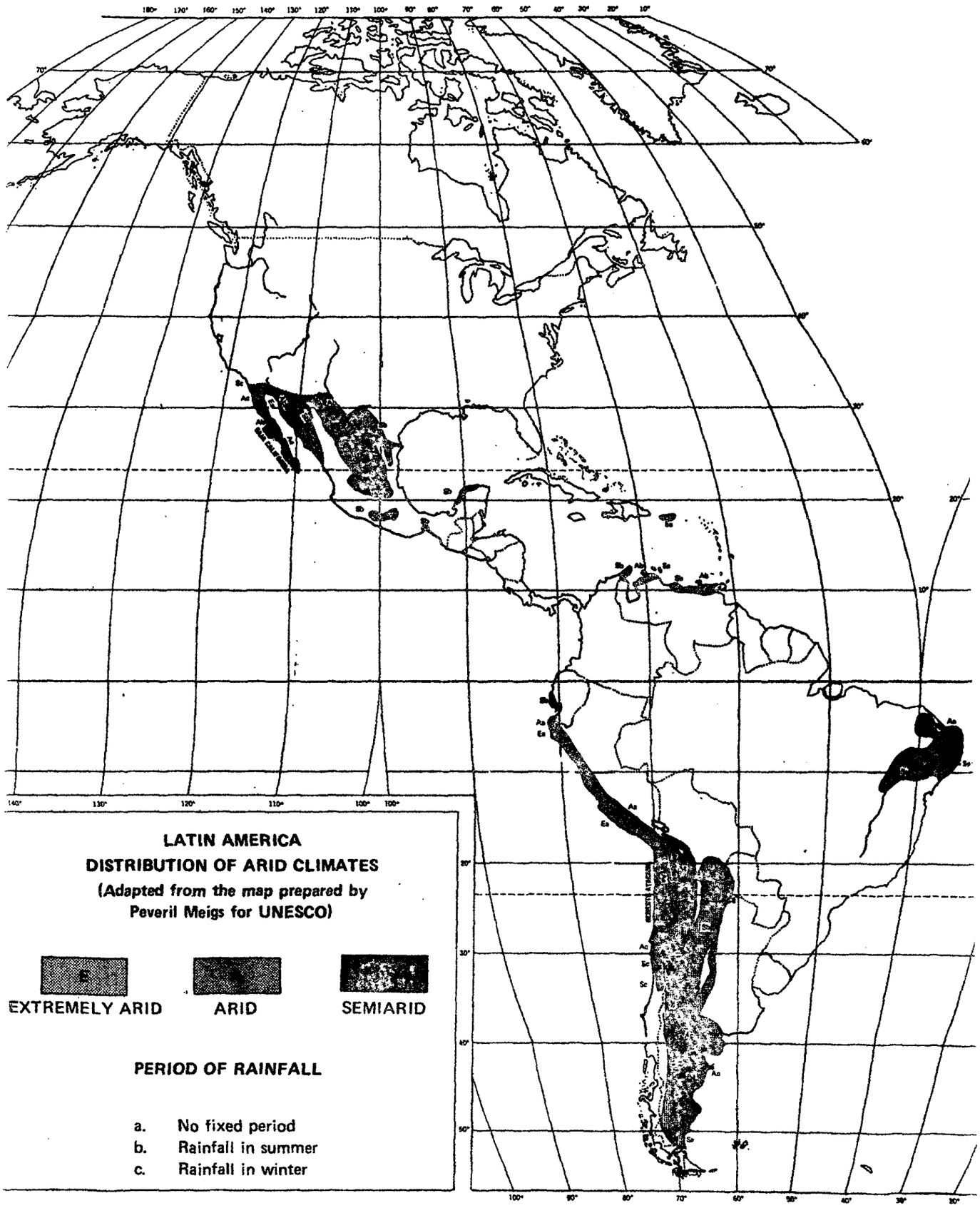
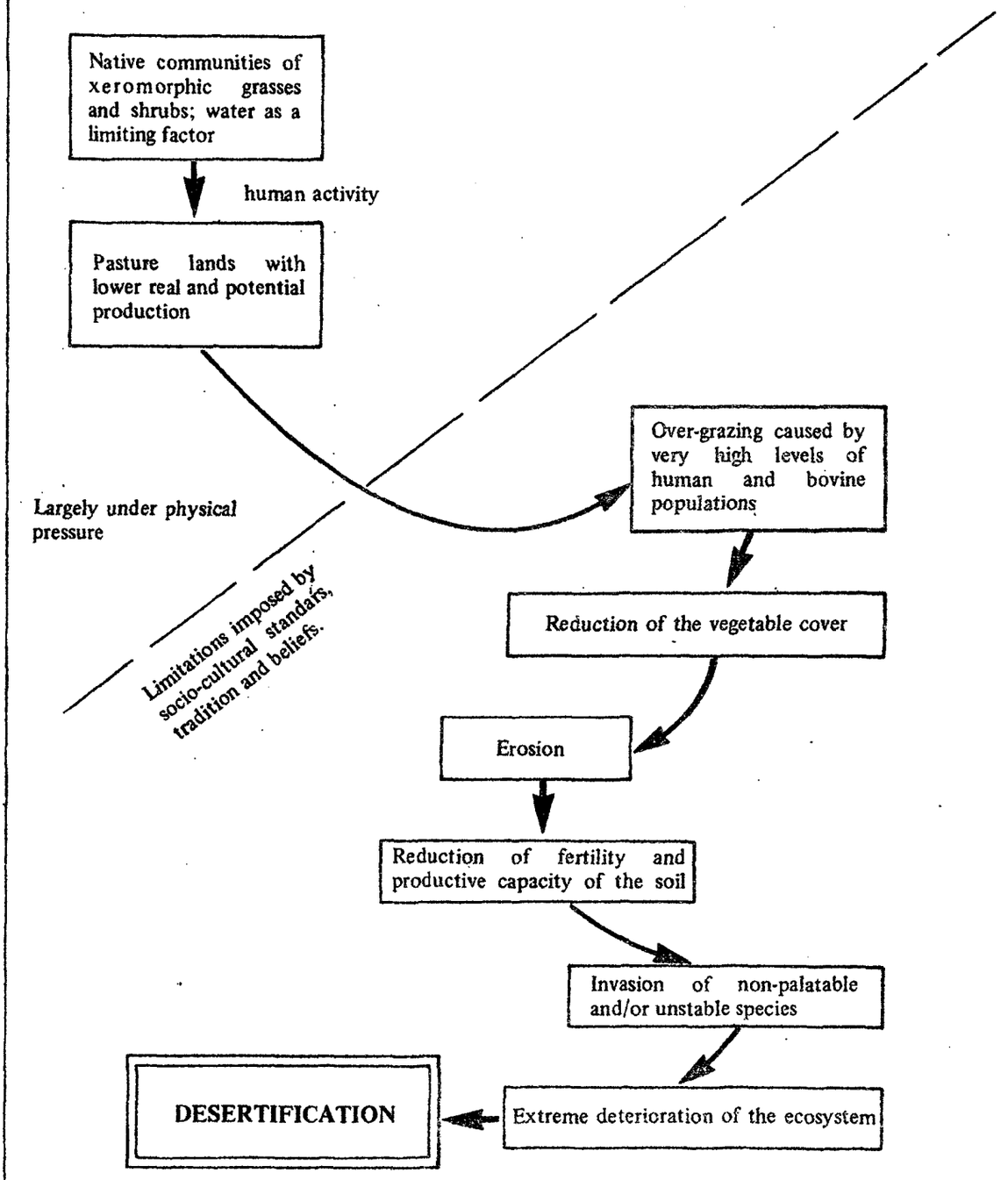

LATIN AMERICA
DISTRIBUTION OF ARID CLIMATES
(Adapted from the map prepared by
Peveril Meigs for UNESCO)
EXTREMELY ARID
ARID
SEMIARID
PERIOD OF RAINFALL
a. No fixed period
b. Rainfall in summer
c. Rainfall in winter

Figure 1

Schematic diagram of conditions, events and problems in arid and semiarid pasture lands. (Adapted from UNESCO. Reference in footnote 10).



OPENING STATEMENT BY

DR. MOSTAFA K. TOLBA
EXECUTIVE DIRECTOR
UNITED NATIONS ENVIRONMENT PROGRAMME

AND

SECRETARY GENERAL
UNITED NATIONS CONFERENCE ON DESERTIFICATION

AT THE

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

SANTIAGO, CHILE

FEBRUARY 23-27, 1977

Check against delivery

Mr. Minister, Mr. Executive Secretary, distinguished participants and observers, ladies and gentlemen,

1. It gives me great pleasure to greet you at this opening session of our Regional Conference for the Americas. With this meeting we are entering upon the final stage in our preparations for the United Nations Conference on Desertification authorized by the General Assembly in December 1974.

2. This is the first of four such regional preparatory meetings. It will be followed in March and April by meetings for the Mediterranean area, for Africa south of the Sahara, and for Asia and the Pacific.

3. I would like, at this point, to express my grateful thanks to my friend and colleague Enrique Iglesias, the Executive Secretary of the Economic Commission for Latin America, for the kind words he extended to me at the beginning of his statement and for the considerable effort he and his colleagues have made to bring this meeting together at short notice. I share the thoughts that he has already expressed to us about Latin American concerns. I wish to address more or less the same questions but with perhaps somewhat more emphasis on the state of preparations for the Conference and on what we expect from this meeting.

4. May I also express my pleasure in the widespread interest in this meeting, evidenced by the presence of participants from so many countries. Our proceedings, I am sure, will be followed with keen interest by many people both in the developed and the developing countries.

5. I wish to express deep gratitude to the Chilean Government through you Mr. Minister for the keen interest you showed to see this meeting held here in ECLA in this beautiful city of Santiago. This came as no surprise to me. We have been closely following in UNEP, the concern of the Chilean Government for the environment at large and the problem of combatting desertification in particular. You have participated actually in the preparation for the Conference on Desertification. The case study on desertification in Chile and the full participation in the feasibility study on monitoring the process of desertification on a number of Latin American countries are ample evidence.

6. Why did the General Assembly ask for a Conference on Desertification? What were the circumstances that led to this decision? As we all remember, it was the great drought which affected the countries of the Sahel for some six years prior to 1973 that aroused world concern, first to help relieve the mass human suffering it caused, and second to try to understand what may lie behind such drastic weather fluctuations.

7. Largely as a result of the Sahelian drought, a number of resolutions by the United Nations organizations and the General Assembly began to address the problems of desertification in the early 1970s. At its sixth special session in 1974, the General Assembly recommended that the international community urgently take concrete measures to stem the spread of deserts and assist the economic development of affected areas. The Economic and Social Council in the same year requested all the concerned organs of the United Nations system to pursue a broad attack on the drought problem. Decisions of the Governing Councils of the United Nations Development Programme and the United Nations Environment Programme, among other governing bodies of United Nations organs and specialized agencies, emphasized the need to undertake studies on the extent of drought, and to draw up appropriate action programmes.

8. Finally, on 17 December 1974, at its twenty-ninth session, the General Assembly passed a resolution on desertification presented by the African group. There was a remarkable convergence of view on the need to undertake now a world programme of effective action to contain desertification and, where possible, to arrest the processes involved and reverse them. The General Assembly decided, as a matter of priority, to initiate concerted international action to combat desertification. And it further decided to convene in 1977 a United Nations Conference on Desertification to give impetus to such international action. Since the General Assembly passed its resolution in 1974, drought has been occurring in various areas of the world. Last year France and the United Kingdom, for example, suffered lengthy periods of drought. Right now we are witnessing severe drought in the western part of the United States, the immediate effects of which are anticipated by United States scientists to include restricted agricultural output, a shortage of adequate grazing land, power shortages in areas that rely heavily on hydroelectricity and severe forest fires by late summer. Some United States crop scientists fear that spring wind will begin next month eroding the topsoil across the Midwest, with severe damage to the germinating winter wheat crop.

9. Although drought, aridity and desertification, as you are fully aware, are not synonymous, yet the following definitions might explain their interrelations:

- Aridity is an ecological situation in which water income is less than potential water expenditure (run-off evapotranspiration, etc.). In semi-arid and sub-humid regions, drought is part of the seasonal rhythm of the year and a delicate balance may be maintained during the part of the year when rain falls. Under these conditions, human interference may entail irreparable damage to the dynamic functioning of the ecosystem.

- Desertification is a process caused by human activities whereby the productivity of semi-arid or sub-humid habitats is reduced to a level characteristic of deserts. Desertification shows itself primarily in physical terms: reduction of plant cover, removal of surface deposits (soil), loss of organic matter from the soil, deposition of sand bodies, increased run-off, etc.

10. A few facts and figures, at this juncture, might also help define the magnitude of the problems we are facing:

- Based on climatic data, arid and semi-arid lands make up 36 per cent of the earth's land surface and are inhabited by 628 million people, 16 per cent of the world's population. However, based on soil and vegetation data the total area is equivalent to 43 per cent of the earth's land surface. The difference is accounted for by the estimated extent of man-made deserts (9,115,000 Km2), a collective area larger than Brazil.

- At least two-thirds of the world's nations are directly affected by the desertification process.

- In the Sahelian drought, emergency relief by 1974 approached a value of US$ 200 million. Even with this, estimates of deaths as a direct result of the drought have ranged between 100,000 and 250,000. The loss of livestock is estimated to have been as high as 90 per cent in Mali and 2 million nomadic pastoralists lost more than half of their livestock.

- Today the world's drylands contain 9 metropolitan centres with more than 1 million people each, which aggravates the problem. During the Sahelian drought, where urban population growth rates, already very high at 10 per cent per year, briefly doubled, intensifying the adverse environmental impacts that these urban settlements already exert.

- Although no authoritative figures exist, it is estimated that between 50,000 to 70,000 sq.km. of land are lost annually to desertification and if an arbitrary value of US$ 200,000 per sq.km. is put on this, the annual economic loss due to desertification is in excess of US$ 10 billion.

11. The General Assembly in deciding on the convening of a World Conference on Desertification called for three things. First, it called for all data relating to desertification and its effect on economic development. Second, on the basis of this global assessment it asked for the preparation of a world plan of action to combat desertification. Third, it asked that the United Nations Conference on Desertification consider these questions, adopt a world plan of action, and put the necessary political impetus behind its implementation.

12. In response, the Conference Secretariat has given prior attention to reaching an understanding of the problem of desertification. The studies which form the scientific sub-strata on which our Plan of Action is built, and which I will describe in more detail later, have revealed three basic findings on which there is unanimity among our senior consultants and scientists.

13. The first is that desertification is a result of the interaction of man and an adverse environment and shows itself in declining productivity of the areas affected. This is a self-feeding mechanism; desertification is a process that spreads by its own generation.

14. Secondly, they agree that further research is highly to be desired and will make the task of combatting desertification easier.

Yet they maintain that the problem can be attacked and countered now on the basis of present knowledge. Therefore our Plan of Action places its emphasis on action now.

15. The third consensus reached by our scientists and senior consultants is that the key to the attack on problems of desertification lies in proper land use.

16. Desertification, then, is a human problem. It is the deterioration of dry land ecosystem as a result of human activities, to the point where restoration is impossible except at enormous cost. Deserts are best thought of as areas of sparse or no vegetation, and low biological productivity, due to eficient rainfall. Desertification is seen as the extension or intensification of such conditions.

17. Both Governments, in their political judgement, and scientists, from the point of view of their own specialities, have seen the need for consolidated international activity, under the United Nations, to stop the increasing degradation of fertile and productive land which, as I mentioned earlier, amounts to between 50 to 70 thousand hectares a year. The General Assembly saw the need for preventive action, however difficult that might be to organize and finance, rather than to provide emergency, stop-gap, short-term relief which does not strike at the basic problems, and is considerably more costly.

18. At this point, Ladies and Gentlemen, I should perhaps summarize the way in which we have prepared for the Conference. I will then proceed to comment on the basic documents, by which we have reached our understanding of the problem of desertification, and which have led to the shaping of the Plan of Action.

19. As required by the General Assembly, a small Secretariat was established at UNEP in Nairobi. A United Nations inter-agency task force was established by the General Assembly to assist the Secretariat in its work. This task force comprised representatives of the United Nations, its offices and programmes, as well as from the specialized agencies most concerned.

20. We have drawn up a panel of scientists in the many disciplines which have a bearing on the problem of desertification. This group comprises specialists from all over the world, including scientists of distinction from this continent. These people have come together, often at short notice, to give us the benefit of their advice and guidance. We have also drawn into our scope a number of the scientific and other institutions concerned with these questions. Some of these institutions are major ones of international repute, others are small and little known, but whose work is of great significance.

21. The financing has been arrived at for the most part from the Environment Fund. There was also financial support from the United Nations Development Programme and the United Nations Fund for Population Activities.

22. Our first task in the Secretariat, as I have said, was to try to reach a more profound understanding of the causes and consequences of desertification. It was not possible to carry out a global review of all known data. Instead, with the support of the Governing Council of UNEP, which was named the Inter-Governmental Preparatory Body for the Conference, we made some critical choices. We decided that we needed the best possible scientific knowledge in four areas in their relation to desertification: climate, ecological change, population and society, and technology. These papers have now been prepared, one of them at Chapingo in Mexico, by Agronomist Manuel Anayo Garduño.

23. You have before you, Ladies and Gentlemen, a draft of the synthesis of the four component reviews which we have titled "Desertification: An Overview". It is a preliminary text, and I look forward to learning the views of this meeting on this draft. It has been prepared deliberately in a popular, narrative style. The four component reviews, as we now call them, are somewhat more technical. The review and the overview represent, to a large extent, our assessment of the causes and consequences of desertification.

24. As the component reviews themselves are now in the process of reproduction, they are not being presented to the regional preparatory meetings. They will, however, be before the Conference as background documents. We will have however, before this meeting, valuable country statements describing the extent and nature of desertification and the measure of the success of programmes to arrest this process. We also have the very illuminating statement just made by my colleague, Mr. Iglesias, the Executive Secretary, on the aspects of desertification in the Latin American region, and a paper prepared by Mr. José Emilio Araujo from the Inter-American Institute of Agricultural Sciences at Turrialba on the natural phenomena of desertification in South America.

25. Our global studies are reflected in six case studies of specific locations. The selection of these has been on the advice of our scientists, in consultation with the specialized agencies and of the United Nations, of course, with the Governments themselves. We have tried in these case studies to cover, as far as possible, the main ecological regions, and to study what happens when desertification takes place, and when there is an attempt to introduce regeneration.

26. The case studies were twinned. Two in Iraq and Pakistan deal with waterlogging and salinity in irrigated areas. The two in Niger and Rajasthan in India are of warm season rainfall areas, and the two in Southern Tunisia and Northern Chile are of cold season rainfall. The Chilean case study has only recently been completed.

27. We are most grateful for the financial assistance made available by the United Nations Development Programme, and for the assistance of UNESCO to the Governments concerned in preparing the studies.

28. There was so much interest in this particular aspect of our work that several Governments offered to prepare studies of their own. Those we call associated case studies. There is a study of the Gascoyne catchment in Western Australia, one on recovery in north-eastern Iran, three from China, two from the Soviet Union, one from Israel and one from the United States covering a cold desert in south-east Oregon. These are now being reproduced and will be available to the Conference.

29. We will present a synthesis of these case studies at the Conference, along with the case studies themselves. This synthesis, we hope, will stress the experience gained in programmes of recovery from desertification, and the lessons which can be generally applied when we come to consider the World Plan of Action.

30. I should perhaps add, before going on, that the General Assembly when it adopted its enabling resolution, stressed that the Plan of Action itself should strengthen the indigenous capacity in science and technology in the areas concerned. We felt the best way to do this was to start immediately, and for that reason the studies and the other preparatory work leading up to the Conference have, for the most part, been carried out in scientific and other institutions in the countries most affected by desertification particularly developing countries. I have mentioned Chapingo and I will be able to touch later on other institutions in the Americas which have played a significant role in the preparations for the Conference.

31. The General Assembly also asked us to prepare a world map showing areas affected, and areas likely to be affected by the process of desertification, and giving some indications of the reasons why desertification takes place. Through FAO, in co-operation with UNESCO and WMO, we have prepared a World Desertification Map, at a scale of 1:25,000,000 on a new projection prepared specially for the Conference.

32. Now, a map of such a small scale cannot be a scientific tool. So we have had FAO prepare an experimental map of desertification for Africa north of the equator, and IADIZA (Instituto Argentino de Investigaciones de las Zonas Aridas) has prepared an experimental map of desertification in countries of South America. Both maps show a scale of 1:5,000,000 and I am happy to see the South American map before us in the hall today (as well as the Director of IADIZA, Engineer Virgilio Roig).

33. We have arranged with the University of Bonn for the preparation of a climate/aridity index map, and with the University of Moscow and the Soviet Union Academy of Sciences for a map on drought probability. We will also have, for the Conference, a map on vulnerability prepared by Professor Dregne, Chairman of the AAAS Desertification Committee. These three experimental maps, with an accompanying brochure, will be presented at the Conference, and one will be featured in one of the component reviews.

34. Finally, on the question of maps, when we prepared the case studies and agreed upon a common approach, methodology and terminology, we prepared a synoptic map of each of the areas covered by the case studies. We see, as a result of this experience, the need in the future for a detailed desertification atlas which would be brought up to date from time to time.

35. The activities that I have so far described have been essentially those of establishing the most up-to-date knowledge for the Conference on the causes and consequences of desertification.

36. I turn now to questions of feasibility. Desertification is no respecter of frontiers. In many regions of the world there are problems which countries have in common and could benefit from tackling together. So we examined the possibility of carrying out what we call transnational projects, that is, projects of a regional character involving groups of concerned and affected countries.

37. Activities of this kind are, naturally, far-reaching and ambitious, and are not always easy to design because of the many constraints that apply.

38. However we have carried out a series of studies on the feasibility of such transnational activities. We started with the area of greatest vulnerability which is the Sahel. Here we studied the possibility of a transnational project on the stratification of livestock, involving, initially, seven countries of the Sudano-Sahelian region. We thought it would be possible to reduce the pressure on vulnerable grazing areas by taking of immature cattle, and moving them to moister areas closer to the market for finishing and fattening. This study has been well received by the governments, and we are already taking the initial steps to carry out this long-range project.

39. Secondly, the Governments of practically every country in North Africa are experimenting with major programmes for establishing tree belts, or shelter belts, to contain desert encroachment. The governments themselves have agreed to pool their experience in a common effort. I am happy to report that on 5 February in Cairo, Ministers of Agriculture of three countries signed a protocol which, in effect, accepted the feasibility study for a transnational project to establish a green belt in the northern Sahara. The two remaining North African Governments are expected to sign shortly.

40. A feasibility study of a similar proposal is currently being considered for the Sahelian region. There the ecological conditions are vastly different from those prevailing in North Africa, and we do not yet know to what extent it will be possible to carry out a project of this kind on the southern margin of the Sahara.

41. In Northern Africa and in the Arabian peninsula in Asia there are deep aquifers in which the groundwater is fossil, accumulated in pre-historic times. Because of the ecological changes that have taken place in these areas, these aquifers are no longer rechargeable. The management of the groundwater which these countries have in common is becoming increasingly important, not only because the water is irreplaceable, but also because in some places it may decline in

quality through intrusion of sea water. The Governments concerned have reviewed a feasibility study, and in Qatar towards the end of last year an agreement was reached on a common programme in both areas.

42. In any world programme to contain desertification, a continuous monitoring and assessment of the situation is essential. We decided to choose two critical areas of the world to start monitoring desertification processes. The Governments of Peru, Argentina, Chile, and now Brazil, have joined together to study how best desertification processes can be monitored and assessed in the critical areas of their countries. In addition to ground knowledge, information will be derived from satellite imagery and available air photographs. My colleagues have just returned from Lima where the Governments met to complete the arrangements for such a project.

43. This arrangement in South America has been replicated in Southwest Asia. The Governments of Iran, India and Pakistan have agreed in principle to the monitoring and assessing of the critical areas in their countries in a similar manner, and the Government of Afghanistan has formally agreed to join this transnational project.

44. I have mentioned these feasibility studies in some detail, because we believe we should not wait till the Conference takes place to decide what should be done. Rather we should start now on action to contain and, where possible, to reverse desertification. I am happy to see that the feasibility studies have borne fruit in Government agreements and the decision to work together, and that these common projects have received a broad measure of international support.

45. All these activities form part of the Plan of Action to combat desertification. You have before you, in addition to the summary of the feasibility studies themselves, a draft of the Plan. The basic principles which were taken into account during the preparation of the Plan of Action are stipulated in the introductory part of the Plan. But I should perhaps, at this juncture, mention three of our guiding considerations in preparing the Plan of Action.

46. The first is that we are concerned primarily with man in his environment, and not exclusively with the environment as such. Secondly, while we see the destruction which has taken place as a result to a large extent of man's activities, we see man also as a victim not only as the aggressor. For the most part, the people who live in these vulnerable areas must find their livelihood in ecosystems not of their own making. We know that many emigrate, we know that changes take place, that industry is introduced, that occupations are broadened; but, by and large, the people of these areas remain victims of a condition rather than merely the creators of it. This is important to bear in mind, because much that has been written has portrayed man alone as causing havoc in these extremely friable areas. We do not share fully this view, or take exactly the same approach.

47. Thirdly, while we naturally see the need for every effort to increase food production, we are not concerned immediatly with increasing the productivity of these areas. For we see them, for the most part, as areas that will normally be of low unit agricultural productivity. We are concerned primarily with the restoration, wherever possible, of areas that have degenerated.

48. I should hasten to add that although these areas are of low unit productivity, their total production is enormous in terms of world food supply. In fact, the major part of the world's cereals are grown in drylands, including the great plains of North America.

49. The Plan of Action which you see before you begins, as do the feasibility studies, with assessment and planning. It then goes on to propose measures dealing with population and health, water, land and livelihoods; an examination of alternative energy sources; the need to provide risk insurance against drought; how we can strengthen indigenous science and technology to underpin these activities; and the whole question of supporting measures, including institutional arrangements, the role of international organizations, and the financing of the Plan itself. As far as institutional arrangements are concerned you will see that we do not opt for a new institution. I feel strongly that the existing United Nations mechanisms can carry the responsibility of the follow-up of the results of the Conference. In my view the Environmental Condition Board (ACB) is well equipped to carry the job.

50. The draft Plan you have before you will be further elaborated in the light of the discussions we are holding here this week, the examination the Plan will receive in the other regional meetings, and the review that will take place at the Governing Council of UNEP in May.

51. We are already taking steps to strengthen those parts of the Plan which, in our judgement, require improved formulation. The way we are doing this is to call together small groups of high level specialists with experience on specific topics. We are having one group consider how best we can monitor the human condition and improve family health in the areas concerned. Another group is considering how the international community can increase insurance for peoples at risk, bearing in mind the need not to tamper with traditional insurance systems which exist in every society. We are also working on the strengthening of the section of the Plan which deals with alternative energy sources.

52. We are also, with our colleagues in the United Nations Water Conference, seeing how best the Plan of Action can be strengthened by appropriate contributions to the Conference from the forthcoming Water Conference in Argentina. Periodic consultations have already taken place between the two secretariats and the consultants who have written papers in preparation for the two conferences.

53. Finally, we are convening a high level group of those who have experience in the financing of programmes nationally, bilaterally and internationally, to see how best to organize and administer the financing of the programmes that will arise out of the Plan of Action to combat desertification. We also hope on this occasion to determine with some more precision the orders of magnitude of the funds involved, particularly for the initial period, that is the seven years beginning in 1978. Our preliminary estimate of the outside figure required is in the region of four billion dollars, although I hasten to add that this would only in part call for net additional funds over those we can foresee as being available.

54. Additional activities, in preparation for the Conference, are the information compaign, the workshop planned to follow the Conference where national officers dealing with programmes of combatting desertification would meet to discuss ways and means of implementing those resolutions of the Conference meant for immediate implementation. The last of these activities is the planning for Non-Governmental Organizations to play a significant role in the preparations for the Conference and implementation of its recommendations. Also associated with the preparations for the Conference, we in UNEP, through our training centre in Madrid for Spanish speaking countries (CIFCA), will shortly be holding jointly with IADIZA in Mendoza, Argentina, a course on the ecology of the ecosystems of arid and semi-arid areas of Latin America. I am sure my colleagues will brief you fully on all these activities if you so wish.

55. I now come, Ladies and Gentlemen, to the question of what we can lo for from the regional meetings. These meetings are held in accordance with the General Assembly resolution which requested "as part of the preparatory process for the Conference and in consultation with the Governments concerned ...(and)... in co-operation with the regional commissions, technical meetings at the regional and subregional levels as appropriate".

56. These meetings are the principal occasions on which we can share our thoughts with Governments in the various regions on the preparations for this important Conference and learn from their appointed specialists their views on the approach we are taking to the Conference. In particular, we will review the main documents and proposals for the United Nations Conference on Desertification while these papers are still at a formative stage.

57. Basically, we are expecting three things from the regional meetings:

(i) An understanding of the region's own experience, as reflected in its country papers, and any views that the Governments wish to express, in order to enlarge our knowledge of all the processes related to desertification, its causes and consequences, and to supplement the information we already have.

(ii) We want to know how the countries of the region see the Plan of Action, what refinements they would like to see in it. We want you in this meeting, for example, to discuss fully the format and possibilities for implementation of the Plan of Action. We want you to identify for us what within your region requires immediate action and could be achieved at the national or regional levels within the capabilities of the countries concerned and the limits of reasonable international support. To put it another way, we want you to help as ensure that the Plan of Action is sound, feasible and achievable and not simply a list of lofty recommendations and wishful thinking.

(iii) We also want to know the views of the governments concerned in each region on the feasibility studies to which they are parties; particularly we want to know whether the Governments concerned intend to start implementing the transnational activities before the Conference so that they can report to the Conference on the steps already taken.

58. In conclusion, may I emphasize that high hopes are pinned on this particular meeting to set the tone for the other three regional meetings. I look for that frank, critical and constructive exchange of views which is the hallmark of meetings of experts. I sincerely hope that you will reach concrete recommendations that may be reflected in our further elaboration of the Plan of Action and in our other preparations for the Conference. Your task is difficult, and the time is short, but I have utter confidence in your expertise in the field, and in your ability to achieve our common goals.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

Information Document Nº 1

Organization of work ✱/

1. Officers

Chairman	Mr. Carlos Alberto Dulcic Belloni (Chile)
Vice-Chairmen	Mr. Alejandro Quesada Ramírez (Costa Rica)
	Mr. Dillard H. Gates (United States)
Rapporteur	Mr. Gustavo A. van Gelderen (Argentina)

2. Hours

9:30 to 12:30

2:30 to 4:00

4:30 to 6:30

3. Rules of Procedure

Normal rules of the Economic Commission for Latin America

4. Wednesday 23 February

9:30 to 11:00 - Meeting of Heads of Delegations

11:00 to 12:30 - Statements by Mr. Enrique V. Iglesias, Executive Secretary, ECLA
General Mario Mac-Kay, Minister of Agriculture, Chile
Dr. Mostafa K. Tolba, Executive Director, UNEP (in his capacity as Secretary-General of the Conference)

2:30 to 6:30 - Agenda item 4
Overview of case studies and maps to be discussed (20 minute presentation by Prof. Kassas, Assistant to the Secretary-General of the Conference)
Country statements

✱/ As approved by the informal meeting of Heads of Delegations.

5. Thursday 24 February

9:30 to 12:30 - Continue discussion of agenda item 4

2:30 to 6:30 - Agenda item 5
Summary of feasibility studies (15 minute presentation by Dr. Karrar, Assistant to the Secretary-General of the Conference)
Monitoring in South America (10 minute presentation by Dr. Karrar)
Plan of Action (20 minute presentation by Dr. Rosanov)
Discussion of Plan of Action and specific recommendations

6. Friday 25 February

9:30 to 12:30 Continue discussion of agenda item 5

2:30 to 6:30 If necessary, continue discussion of agenda item 5 and, when concluded, take up item 3
Presentation by Mr. Ralph Townley, Director of the Secretariat of the United Nations Conference on Desertification

Additional background documents (including UNITAR study and IFIAS study on Drought and Man)

Arrangements by the Conference (including information campaign, post-Conference workshop for implementation of Action Plan and involvement of non-governmental organizations

7. Saturday 26 February

11:00 to 12:30 - Adoption of the report of the Meeting, which is to consist of five pages of generally agreed topics. Some countries may have specific considerations and recommendations which could be added as annexes

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

Information Document Nº 1/Rev.1

Organization of work *

1. Officers

Chairman	Mr. Carlos Alberto Dulcic Belloni (Chile)
Vice-Chairmen	Mr. Alejandro Quesada Ramírez (Costa Rica)
	Mr. Dillard H. Gates (United States)
Rapporteur	Mr. Alberto Emilio Montbrun (Argentina)

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77-2-0400-

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Summary of feasibility studies (15 minute presentation by Dr. Karrar, Assistant to the Secretary-General of the Conference)
Monitoring in South America (10 minute presentation by Dr. Karrar)
Plan of Action (20 minute presentation by Dr. Rosanov)
Discussion of Plan of Action and specific recommendations

6. Friday 25 February

9:30 to 12:30 Continue discussion of agenda item 5

2:30 to 6:30 If necessary, continue discussion of agenda item 5 and, when concluded, take up item 3
Presentation by Mr. Ralph Townley, Director of the Secretariat of the United Nations Conference on Desertification

Additional background documents (including UNITAR study and IFIAS study on Drought and Man)

Arrangements by the Conference (including information campaign, post-Conference workshop for implementation of Action Plan and involvement of non-governmental organizations

7. Saturday 26 February

11:00 to 12:30 - Adoption of the report of the Meeting, which is to consist of five pages of generally agreed topics. Some countries may have specific considerations and recommendations which could be added as annexes

ADDRESS DELIVERED BY GENERAL MARIO MAC-KAY JARAQUEMADA, MINISTER OF AGRICULTURE, AT THE UNITED NATIONS CONFERENCE ON DESERTIFICATION REGIONAL PREPARATORY MEETING FOR THE AMERICAS, SANTIAGO, 23 FEBRUARY 1977

It is a source of deep satisfaction to the people and the Government of Chile that their country should have the honour of serving as the venue for the United Nations Conference on Desertification - Regional Preparatory Meeting for the Americas. We extend our warmest welcome to the distinguished delegations of the various countries represented here, to the high officials of the United Nations and to all those who are joining us on an occasion when the serious problem of the desertic or semi-desertic areas is to be studied with a view to drawing up a programme of specific action for their control or recovery.

Since the very dawn of the history of man such processes of deterioration of his lands have taken place, with disastrous consequences. The earth is full of dumb witnesses to these happenings, and if we could acquire a thorough knowledge of how and why they have come about, we should perhaps be able to forestall similar phenomena.

We do know, of course, that it is man himself who is largely responsible for the devastation of land that once was fertile. Today no one can remain indifferent to the fact, still less to the imperative necessity of making a study in depth of the arid regions and the process of their encroachment, in order to discover methods of control which will not affect their intrinsically delicate ecology.

The United Nations could not have taken a more praiseworthy step, considering that almost one-third of the earth's whole surface is desertic or semi-desertic, and that fifteen per cent of its population live - if that is the right word - in those regions.

Chile too has a large and important affected area, and can well understand the world significance of the problem with which we are concerned. It is by joining forces, on a regional and world scale, with complete exchange of information, that we shall be able to attain the United Nations' objective: the drawing-up of a plan of action to combat desertification.

We are presenting to this meeting a case study of the existing situation in an area in Chile, which we hope will help to serve ends pursued here.

In welcoming you to the present meeting, we should like to wish you a pleasant stay in our country, and, above all, every success in obtaining positive results that will signify a valuable contribution to the World Conference in Nairobi.

Thank you very much

UNITED NATIONS CONFERENCE ON DESERTIFICATION
REGIONAL PREPARATORY MEETING FOR THE AMERICAS
Santiago, Chile, 23-26 February 1977

STATEMENT BY MR. ENRIQUE V. IGLESIAS,
EXECUTIVE SECRETARY OF CEPAL, AT THE OPENING MEETING

It is a great pleasure for us in CEPAL to have this opportunity of collaborating with the United Nations Environment Programme, to which the General Assembly entrusted the organization of the Conference on Desertification, in the holding of this Regional Preparatory Meeting for the Americas which represents a further step in the series of joint activities undertaken by our two agencies.

The fundamental purpose of this meeting is to serve as a forum where the countries of the region can exchange experience and views so that they can take part in a better-informed manner and with a true regional approach in the World Conference on Desertification which is to be held in Nairobi.

With this new conference, the United Nations is pursuing its task of tackling the main problems which affect the development and well-being of mankind. Closely related as it is with the subjects discussed at the Conferences on Water and on Science and Technology, the problem of desertification was an aspect which could not be left aside.

The distinguished Executive Director of the United Nations Environment Programme, whom we are honoured to have here with us today, will deal more fully with the objectives and organization of the World Conference on Desertification and will thus provide us with the frame of reference of the present Regional Preparatory Meeting. For my part, I simply wish to stress CEPAL's interest in adding its efforts to those of the Governments, so that this Meeting may produce a realistic view of the problems of the arid and semi-arid

77-2-0378-80

zones in America. This, together with the contributions of the other regions, will provide a concrete basis for the work of the World Conference.

The CEPAL secretariat is particularly interested in desertification. This could hardly be otherwise, considering that roughly 25 per cent of the region's area is arid or semi-arid and to a greater or lesser extent exposed to the process of desertification. Despite the fact that it is the continent with the greatest water resources, South America also has some of the world's most arid areas, and among the countries of the region there are some, such as Argentina and Mexico, whose area is more than 60 per cent arid or semi-arid.

CEPAL has not, to date, undertaken any specific activity on desertification, but it has touched indirectly on some of the questions which form the subject of this Meeting in its studies on the development of water resources and on socio-economic development in general.

The arid and semi-arid zones of Latin America

I shall now venture to outline the situation and extension of the arid and semi-arid zones in our region and the risk they run of undergoing desertification processes. These zones fall into four main areas: north-western Mexico; the extreme North of South America (La Guajira and north-western Venezuela) also including the neighbouring islands; north-western Brazil; and the great diagonal desert covering south-western Ecuador, the Peruvian coast, northern Chile, the Bolivian altiplano and north-western, western central and southern central Argentina. In addition, much of Chilean and Argentine Patagonia is semi-arid, although its characteristics are very different from those of the above areas.

In these zones the risk of undergoing a process of desertification ranges from very high in hilly land where population pressures are heavy, as in much of Mexico and the foothills of the Andes, to rather remote in the sparsely populated plains such as the Chaco (Argentina, Bolivia and Paraguay) or Patagonia. The stable natural deserts of Baja California, the Peruvian coast and northern Chile are

another matter: because of climatological factors the desert itself is not reversible, and the only alternative is to bring in water from sources situated outside the area.

All these zones, however, share a common problem. For their development the countries need to make use of all their resources, and the arid and semi-arid areas should be exploited at the highest possible level of use compatible with the need to conserve their productive potential for future generations.

On the causes of desertification

The periodic recurrence of drought with its sequel of economic loss and social problems has led the climatologists of the region to study the trend of diminishing rainfall, particularly in the great diagonal desert in South America. However, since climatic cycles may be extremely long and the period covered by existing meteorological observation is generally less than 100 years, definite conclusions cannot be drawn, despite the interesting studies which have been carried out. Nevertheless, there is a relationship between the frequency of drought and desertification, since it is during droughts that the livestock, in order to survive, destroy the available vegetable cover which does not regenerate because the soil, once exposed to the subsequent action of the agents of erosion (water and wind) loses its fertile elements.

Furthermore, the droughts themselves are a problem of great importance in the countries which have semi-arid regions because of the damage caused. During the severe drought which ravaged the north and centre of Chile between 1968 and 1970 it is estimated that in the agricultural year 1968-1969 alone the direct losses in the agricultural sector amounted to US$ 170,000,000 at current values; if in addition one considers the losses sustained by the mining and industrial sectors because of the shortage of hydroelectric power and the indirect losses represented by unsown fields one can appreciate the value of studying the likely frequency and intensity of periods of drought so as to take in advance the necessary precautions to reduce the damage.

The semi-arid areas are subject to droughts periodically and inevitably, but man has sufficient ingenuity to be able to find a way of developing and selecting the necessary measures in good time to prevent these critical periods from turning into catastrophes.

Although it is true that the destructive cycle which leads to desertification begins in periods of drought, it is man's persistence in overexploiting areas of limited productivity and the lack of knowledge of the appropriate technology which lead to desertification as such.

Social and demographic aspects

In the areas of Latin America which are most affected by the desertification process there is a combination of various elements. In the first place the semi-arid areas and especially those situated on mountain slopes have exceptionally mild climates and have always been free of malaria, yellow fever and other endemic diseases, so that as a result these areas were the first to be settled and worked by many generations. This demographic pressure, combined with the topographical conditions typical of the sierras, makes the land highly vulnerable to erosion. The introduction of the goat, with its indiscriminate grazing habits, considerably accelerates the process.

Mining, the main source of income of some arid areas, has led to the felling of forests so as to use the wood for props and fuel, thus adding a new factor to the desertification process.

The very antiquity of the human settlements in these areas explains why types of social organization and land ownership which differ considerably from those prevailing in the remainder of the various countries still subsist, and this adds an additional difficulty to the solution of their problems.

In addition to this phenomenon there is the need to subsist of the people who inhabit the semi-arid areas, and it would not be realistic merely to indicate the need to avoid overexploiting these areas or the measures to replant vegetation without solving the problem of the subsistence of their inhabitants.

Desertification is not so much a problem of knowledge as one of the lack of resources for explaining the existing knowledge and proposing viable alternative strategies in accordance with the cultural and socio-economic conditions. Within the region, as in the rest of the world, there are many examples of the transformation of desert areas into veritable cases, but this involves the investment of major resources which the countries are not always in a position to devote to these areas.

It is thus extremely important to include on the agenda of the Conference the study of the demographic, social and behavioural aspects of the people who inhabit these areas.

Ecological damage

The effects of the inappropriate use of soils and vegetation can be observed throughout the region. In Mexico 30 million hectares, or 15 per cent of the national territory, was subject to serious erosion in 1969 according to the Plan Nacional Hidráulico and it is estimated that the same proportion is applicable to the region as a whole. In Argentina it is reported that of the 25 million hectares of hardwood forests prospected at the end of the previous century, only 16 million remain.

In the north of Chile it may be observed that the indigenous species of forage plants have almost become extinct and only vegetable species of little or no value remain. In Ecuador the abundant agricultural production which used to be obtained in the Santa Elena peninsula and the south-east region may be contrasted with the current desolation of this region. In Venezuela the states of Falcon and Lara, the cradle of the first stable populations of this country, are seeing how, in the wake of the herds of goats, erosion is destroying their soils.

In the areas of stable deserts life is concentrated in the valleys which cross them and are irrigated with water either from the high cordillera or from other valley basins by means of transverse channels. This means that areas of total desert are found alongside valleys which are always green.

Highly specialized technology is needed to successfully cultivate these types of valleys, since problems of soil salinization easily arise, and the region has had some bitter experience of these.

It is interesting to note the research carried out in Peru on irrigation systems which have presented these types of problems and in particular the case of the San Lorenzo irrigation scheme, which has also been studied from the point of view of the environment in the Water, Development and Environment (ADEMA) project sponsored jointly by UNEP and CEPAL. At the same time, it is possible to obtain a very high agricultural output from this type of valley, precisely owing to the lack of any rainy season, which makes it possible to obtain several crops a year; in Peru, 50 per cent of the gross agricultural product comes from the coastal valleys, which lie in a completely desert area. In Argentina, 30 per cent of this product is obtained from irrigated areas within semi-arid zones.

The complementarity between the cultivation of irrigated valleys and the surrounding areas raises interesting options, and many countries of the region would be interested to learn about the existing experience in this field.

Special techniques for arid zones

Research is being carried out in the region on various technological aspects related to arid zones; in several cases assistance is provided by United Nations specialized agencies and other international institutions. Among the original experiences of special crops in arid zones, it is of interest to mention the Chilean experience in the cultivation of the tamarugo, a tree growing in the salt deserts of the north, whose leaves and berries can provide food for sheep and even cattle, permitting a high animal population density in that zone. Also highly promising is the research designed to identify autochthonous species of forage bushes with a view to promoting their reproduction, as well as the introduction of foreign species suited to the conditions prevailing in the region.

It is also interesting to note the possibility of reviving autochthonous techniques of pre-Colombian cultures which, since they flourished in arid or semi-arid areas, could be especially suited to those zones.

As regards the use of solar energy for household purposes, some interesting experiments are being made. In some desert areas, as in the north of Mexico and Chile, the atmosphere is completely clear almost throughout the year, so that they offer great advantages for the use of solar energy. In other cases, as in some parts of the Altiplano, wind energy can be used to raise water from the sub-soil. Another question that has also been studied in the region is the use of mists and dew both to obtain water for household purposes and to help restore the vegetable cover on coastal hillsides. In Peru, in particular, interesting techniques have been developed in this field.

Institutional organization

The management of arid and semi-arid regions (prone to desertification) is somewhat complex; it requires the co-ordination of action and knowledge in various specialties such as climatology, ecology, soil management in the broadest meaning of the term, social action in some cases at a very low educational level, and the promotion of sometimes fairly complex techniques, all this under the menace of periods of drought when emergency measures have to be taken which in some cases may mean delaying the action already initiated. Some special type of institutional organization is necessary for the purpose. There is evident interest in the region in setting up commissions to co-ordinate the work of the various institutions, either only during drought periods or on a more continuous basis so that such disasters can be confronted with more efficient preparation and a trained administrative structure.

In this field, too, it is extremely useful to learn about other experiences in order to adopt the best measures and avoid failures.

We therefore welcome this venture of the United Nations aimed at making a complete study of the many causes leading to desertification and at disseminating appropriate information and experience not only

in order to arrest the advance of the desertification process and as far as possible reverse it, but also to enable the inhabitants of arid and semi-arid zones to have means of subsistence and economic incentives comparable with those of the inhabitants of other regions in each country.

Included in the agenda of this meeting is consideration of the draft Plan of Action proposed by the secretariat of the Conference. We believe that this Plan should reflect the concerns of the countries of the region and lead to specific proposals that will genuinely serve their interests. The proposed draft is very broad in scope and not all its recommendations are necessarily applicable to the region. Its content should be reviewed at this meeting and perhaps it will be possible to devise a group of measures that will be of real significance for Latin America.

Whatever the resources available for the future activities that will have to be undertaken as part of the Plan of Action, their success will depend on the creation of artificial ecosystems designed within the restrictions imposed by the local environmental conditions of each arid or semi-arid zone in the region.

The implementation of the Plan of Action will require the co-ordinated efforts of the governments, the United Nations family of institutions and other international agencies. CEPAL will be glad to undertake the tasks assigned to it and will co-operate with all the other institutions in seeking solutions to the problems created by desertification.

It only remains for me to reiterate the interest of this secretariat in the subject you are going to discuss. The contribution of your knowledge about such difficult areas as arid and semi-arid zones will be most helpful to us in broadening our view of both the problems themselves and the ways of solving them.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 1

Proposal by the delegation of Costa Rica

It is proposed that out of respect for the integrity of the Spanish language and as a basic reference for our future discussions the term "desertificación" should be replaced in Spanish by desertización, and that this term should be appropriately defined. To this end the delegation of Costa Rica ventures to suggest the following definition:

DESERTIFICATION: (from desertum = desert)

Direct or indirect human activity which results in the diminution or elimination of normal biological production in any part of the globe. Desertification occurs equally on land, in salt or fresh waters and in the atmosphere itself; in torrid, temperate and cold sectors, and in ecological conditions ranging from typically arid to extremely fertile. Desertification alters to a varying degree the climax of the ecosystem in which it occurs, interrupting the normal phylogenetic process. Its action is always harmful to the biological environment most favourable to man. The fundamental causes of desertification include the following: improper deforestation; overgrazing; mismanagement of agricultural land; land-cleaning by burning; contamination; urbanization and other infrastructural works. To prohibit desertification wherever possible and mitigate its harmful effects in all other cases is one of the fundamental tasks of ecologists and planners.

77-2-0391

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 2

Proposal submitted by the delegation of Costa Rica

Bearing in mind that the struggle against desertification in degraded ecosystems includes the restoration and amelioration of the flora and fauna; that, in ecologically similar but geographically distant conditions, evolution has produced different useful animals and plants which could be complementary for agricultural purposes; and that the Himalayan (Pamir-Tibet-Kashmir etc.) and Andean (Altiplano, intermontane valleys, etc.) mountain ranges are in such a position, the delegation of Costa Rica proposes that this Meeting should request FAO to promote exchanges of biological packages between Andean and Himalayan experimental stations and agricultural extension centres. These packages would include, on the one hand, llamas, alpacas, vicuñas, pacovicuñas, guanacos, chinchillas, etc., in exchange for yaks, highland zebus, dzos, horses, sheep, kiangs, bharals, etc.; and on the other, high altitude potatoes (imillas), ollucos, ocas, quinoa, cañigua, tarhui, long-spiked wild barley, carretilla, huacatai, tumbo, lucma, molle, etc. in exchange for suitable forest and fodder species, oats, barleys, peas, etc. An exchange of this kind could double the agricultural possibilities of both areas, with obvious socio-economic benefits for the inhabitants of the two "Roofs of the World" which are undergoing a process of desertification.

77-2-0409

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 3

Proposal by the delegation of Costa Rica

Since the time when the first herds of horses and cattle appeared in the new continent, a process of desertification by overgrazing began. In the course of four and a half centuries the adverse selection of forage by the herds themselves has eliminated the soft and edible forage plants in some areas, such as the altiplano of the Andes, so that their place has been taken by secondary cover with such sharp spines that they may even put out the eyes of the grazing cattle.

Overgrazing, for its part, has extended and intensified the aridity of such desert or semi-desert areas as those on the borders of the United States and Mexico.

Overgrazing is accompanied by excessive trampling and the two phenomena lead to compression of the soil and wind and water erosion.

In lateritic land with heavy rainfall, on hillsides and even in plains, overgrazing has produced incongruous strips of quasi-desert.

The delegation of Costa Rica feels that it is unnecessary to go into great detail on this subject since it is so well known to all, but considers it advisable that the Meeting should recommend the countries of America to take measures to arrest the overgrazing which extends deserts and reduces forests in critical areas. Such measures should be aimed at obtaining more and better meat, milk, leather, wool and work from considerably smaller areas than those currently used for grazing. To this end the Meeting should recommend more liberal credit for: fencing designed to reduce the area of grazing land; rotation of pasture land; improvement of pastures; improved breeding of livestock; an increase in the number of drinking-places; health; scientific timetables for cattle management; experimentation and extension work; etc. In this way large areas could be released for intensive agriculture, the excessive pressure on forests unsuitable for other purposes would be alleviated and the process of desertification by overgrazing would be halted.

77-2-0403

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 4

Proposal by the delegation of Costa Rica

In view of the fact that fire is one of the determining causes of desertification, although it apparently benefits certain types of forest such as those of sequoias and certain types of pasture land such as those of guinea grass; that it is a destructive and uneconomic element, although it apparently assists the poorest country dwellers in establishing their farms and deriving profit from their lands; that the burning of forest or pasture land generates temperatures at the soil level of around 400º C which destroy the micro and macro organisms and disintegrate the colloids and together with them the soil granulation and the optimum system of base exchange; that it mineralizes the soil; that it favours the leaching of useful soluble compounds and wind and water erosion; and that it produces other types of serious damage which strike at the very basis of agricultural cultivation, the delegation of Costa Rica proposes that the Meeting should suggest to the FAO that it formulate the most effective dissemination procedures, to be incorporated into the legislation of the countries involved with a view to preventing and controlling all accidental or intentional burning of vegetation which contributes to desertification or reduces the natural fertility of the soils.

77-2-0404

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 5

Proposal by the delegation of Costa Rica

In view of the catastrophic levels being reached by indiscriminate deforestation in the Third World countries, the delegation of Costa Rica proposes that this assembly, through the FAO or directly, should press the governments of the countries concerned to enforce their forest legislation, modernize it or formulate it in order to effectively secure, inter alia, the following goals:

1. On hillsides and watersheds unsuitable for grazing or agricultural purposes: to conserve forests, restore them, or at the most, permit their rational exploitation only under strict control.

2. In all types of water basins: to maintain or restore the forests, which prevent erosion, ensure the normal percolation of rainfall and consequent maintenance of the underground water tables, assist the natural recycling of the elements of fertility, reduce the likelihood of destructive floods and silting in dams, correct divergent water-courses and avert other negative consequences caused by irrational deforestation.

3. To maintain or restore strip forests along the rivers of the steppes;

4. To establish a complementary and scientific rotation between forests, pastures and arable land.

5. To prohibit any use of forests which is not authorized by the national body responsible for scientific forest administration.

77-2-0405

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 6

Proposal submitted by the delegation of Costa Rica

Road and industrial facilities, urbanization and many other infrastructural works which are unavoidable in achieving progress, are converting considerable areas into desert at an increasing pace. No less than 400 million hectares of the earth have been made waterproof in this way. Rain neither wets nor is retained by such soil and it runs off with varying intensity towards the sea. The 200 million metric tons which the world's population weighs have replaced a much bigger tonnage of plants and animals of the original ecosystems, and this is preventing the natural return to the soil of an equally large quantity of waste necessary for fertility and soil development. Of the 2,000 million tons of human excreta a year, plus a further large quantity of various kinds of waste, a major part is carried to the sea, taking it away from the soil to which it belongs and thus altering the neritic ecosystems in particular. The oxygen stored by micro-organisms for breaking down this material asphyxiates enormous quantities of marine fauna, inverts the vegetable/animal ratio of the biomass and, although there is a greater abundance of phytoplankton, reduces the possibilities of its faunal utilization. If to this we add the considerable and sometimes definitive loss even of such immobile elements as assimilable phosphorus, which is carried to the bottom of the sea, the problem becomes even more serious.

On the basis of the alarming developments in connexion with these facts, the delegation of Costa Rica proposes that this meeting should bring pressure to bear on governments and on the sources of international credit so that they will introduce or intensify the treatment and agricultural use of waste waters and will as far as possible reduce the unnecessary desertification caused through urbanization and other related works.

77-2-0406

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

Santiago, Chile, 23-26 February, 1977

Conference Room Paper Nº 7

Item 3

Arrangements for the United Nations Conference on Desertification

A STATUS REPORT ON THE LINKS BETWEEN THE UNITED NATIONS WATER CONFERENCE (14-25 MARCH, 1977 AT MAR DEL PLATA, ARGENTINA) AND THE UNITED NATIONS CONFERENCE ON DESERTIFICATION

A NOTE

BY

ALAGAPPA ALAGAPPAN
(United Nations Water Conference
and CNRET representative)

23 February, 1977

77-2-0414

1. A Secretariat colleague remarked today that the count down has begun for the United Nations Water Conference to begin from 14 March 1977 until 25 March 1977 at Mar del Plata, Argentina. This Conference will be of particular interest to participants ot this regional preparatory meeting for the United Nations Conference on Desertification.

2. The Secretary General of the United Nations Water Conference Mr. Yahia Abdel Mageed, former Minister of Irrigation and Hydroelectric power of Sudan has requested me to convey his greetings to all members of this group and to state that the United Nations Water Conference will transmit a report on Desertification with recommendations of relevance to the United Nations Desertification Conference. This report will be drawn from the documentations prepared for the United Nations Water Conference both at the regional and global levels. A perusal of the recommendations of the regional preparatory meetings indicates that they do deal with some subjects of central concern to the United Nations Desertification Conference. These include especially, droughts mitigation, conservation and efficient use of water, etc. Attention of this group is especially invited to the comprehensive report of the regional preparatory meeting of the countries of Latin America and the Caribbean for the United Nations Water Conference held at Lima, Peru, from 30 August to 3 September 1976. (E/Conf.70/5.)

3. The ECOSOC in its resolution 1979 (LIX) of 31 July 1975 specified that links be established between the United Nations Water Conference and the United Nations Desertification Conference. This resolution requested the Secretary General of the United Nations Water Conference to ensure that throughout the process of the preparatory work for the United Nations Water Conference full co-ordination with the preparatory work for the Desertification Conference in order to ensure that there is no duplication at all but the fullest co-ordination and complementarity. In accordance with this resolution, the United Nations Water Conference Secretary General has made efforts to co-ordinate with the Secretary General

of the United Nations Conference on Desertification through the exchange of information and periodic meetings between the two secretariats. Representatives of the United Nations Water Conference have attended the meetings of the Inter-agency Task Force which has assisted the preparation of the Desertification Conference. Representatives of UNEP have participated in meetings of the ACC Sub-Committee on Water Resources Development which has co-ordinated the contributions of the United Nations system to the Water Conference.

4. Some of the objectives of the United Nations Water Conference such as organization of national water committees and regional preparatory meetings have been accomplished. The Secretary General of the United Nations Water Conference wishes to record his appreciation to the UNEP for the assistance received in planning and financing the regional preparatory meetings to the United Nations Water Conference.

5. The documentation now available to the United Nations Water Conference include the "Consolidated action recommendations" (E/Conf.70/9), which brings together and synthesises all action proposals approved by Governments at the five regional preparatory meetings held under the auspices of each of the regional commissions during the second half of 1976. (E/Conf.70/4 to E/Conf.70/8.)

6. The Secretary General of the United Nations Water Conference in order to draw attention of the world to some of the key problems took the initiative to have the following reports issued as indicated below:

(a) "Water for Agriculture" prepared by the United Nations Water Conference Secretariat and FAO.

(b) "Community Water Supply and Sanitation" prepared by WHO in co-operation with the IBRD.

(c) "Technical co-operation among developing countries in the water sector" prepared in co-operation with the CNRET.

(d) "Network, resources and training requirements on water assessment" prepared in co-operation with UNESCO and WMO.

7. In addition the major documents that have been prepared as background material for the Conference are:

(a) "Resources and Needs: Assessment of the World Water Situation" (E/Conf.70/CBP/1).

(b) "Promise of Technology: Potential and Limitations"

(c) "Policy options" (E/Conf.70/CBP/3).

Mention must be made of the report of the ACC and the ECB "Present and Future Activities of the United Nations System in Water Resources Development" (E/Conf.70/CBP/4).

8. Member Governments have presented more than 230 thematic papers covering a broad range of technical and policy experience. An overview summary and analysis of these papers has also been issued indicating the gaps as well.

9. At the request of the Water Conference Secretariat some important reports have been prepared including "Water Law and Legislation: How to use them to obtain optimum results from Water Resources" by Mr. Guillermo J. Cano; "The Design and Evaluation of Institutional Arrangements for Water Planning and Management" by Prof. Charles V. Home and "Non-conventional water resources: some advances in their development" by Mr. M. Kantor. A special session was organized by the International Association for Water Law at Caracas, in February 1976 to support the United Nations Water Conference. The IWRA held a special congress at New Delhi from 12-15 December 1975 on a special theme "Water for Human Needs" and recommendations emanating from this congress have also been made available. Of special interest is the report of the IWRA on "Appropriate technology for water resources development". The Centre for National Resources, Energy and Transport in co-operation with the Government of Hungary have issued two volumes covering the proceedings and documentation of the Seminars on River Basin and Inter-basin Development held in Budapest in September 1975. As a supplementary activity the Government of Argentina through its National Commission

is organizing a series of 14 scientific and technical meetings on important themes covering the spectrum of water resources subjects.

10. The preparations for the United Nations Water Conference have been initiated and supervised by the Committee on Natural Resources which has also acted as the Preparatory Committee for the Conference and held a special second session for this purpose in early 1977.

11. The United Nations Water Conference is endeavouring to promote a level of preparedness at all levels, nationally, regionally and internationally. Integrated water management and formulation of appropriate national water policy in each case is the aim. Much effort has gone into the preparations for the United Nations Water Conference by Member Governments, the United Nations system of organizations and non-governmental organizations, co-operation of the two Conference Secretariats has helped to achieve better results.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper № 9

Agenda item 5

A NOTE BY ALAGAPPA ALAGAPPAN REPRESENTATIVE OF THE
UNITED NATIONS WATER CONFERENCE SECRETARIAT
AND THE CENTRE FOR NATURAL RESOURCES, ENERGY
AND TRANSPORT

77-2-0433

1. A global United Nations Conference on Technical Co-operation Among Developing Countries is to be convened by UNDP in Argentina from 27 March to 7 April 1978. The concepts and mechanisms that are currently being developed for this Conference will be of interest especially under Section F, Strengthening of Indigenous Science and Technology and also probably under Sections G, H and I depending upon the type of actions the Desertification Conference wishes to take.

It is recommended that the scope for TCDC in desertification be assessed and steps be taken to initiate actions in this field.

2. An improved information base and exchange of experience among the concerned developing countries is a first step to be taken. Where research centres and institutes highly specialized in some of the concerned disciplines exist within a developing country or within a region they may be designated as lead agencies to collect and disseminate information. Division of labour among the institutes and institutional arrangements to ensure a regular and continuous flow of reliable data will be of value.

3. An inventory of research, education and training facilities that already exist and the extent to which these can be shared with other developing countries will be of practical value.

4. A roster of experts at the national, sub-regional and regional levels should be established. Where appropriate, consideration should be given to the promotion of national consultancy firms.

5. Joint programmes may be developed among neighbouring countries having common problems.

6. A pilot project may be established for a region at the request of the countries concerned by forming a group of experts from within the countries concerned as far as possible to travel from country to country within the region and:

(a) Establish the needs and match the capabilities of the countries through a detailed on-the-spot study of the situations and;

(b) Help the countries to work out arrangements for the joint utilization of technical personnel and other resources available.

7. The CNRET will be glad, if called upon, to co-operate in implementing the above ideas.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

Conference Room Paper Nº 10

The delegation of Costa Rica, taking up a suggestion by the representative of IIAS, has the honour to submit the following proposal:

Bearing in mind:

(a) The importance of the arid and semi-arid zones of Latin America.

(b) The need to promote basic and applied research aimed at: (i) acquiring knowledge about the components of the ecosystems of such zones, including questions relating to the inhabitants of those areas, the social structure in which they have organized themselves and their economic motivations; (ii) learning the interrelations between those components; (iii) determining suitable action to be taken in order, as appropriate to protect the existing productive capacity, increase that capacity, and develop management systems for the intensive and continous use of the resources.

(c) The desirability of adopting an integral approach in which the physical, biological, economic and social circumstances typifying each problem or situation which affects the fragile ecosystems of arid and semi-arid regions are studied as inseparable factors.

(d) The pressing need to set up machinery at the Latin American level to co-ordinate activities and exchange, assemble and disseminate information in the region.

Recommends:

(a) That consideration be given to the possibility of setting up a Latin American regional centre for the protection and integrated development of arid and semi-arid areas, to work in close co-operation with the national institutions preferably along the lines of systems analysis and the development of models.

77-2-438-60

(b) That arrangements should be made for the functioning, as part of such a centre, of documentation and information machinery connected with the AGRIS and AGRINTER systems and directed towards the collection, processing and dissemination of information on arid and semi-arid areas.

(c) That the activities of the regional centre should also include a training programme for Latin American technicians and scientists who work in arid areas.

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 11

Presented by the Delegation of Argentina

With reference to the remote monitoring programme, the Argentine delegation stated that the Argentine Republic was not officially represented at the Lima meeting. While it recognized the value of the proposed system for monitoring desertification processes, the delegation considered that that system could be viewed as supplementary to other means of combating desertification. Moreover, no official information had yet been given regarding the form and source of financing for the project in question.

To sum up, the Argentine Republic's position is as follows:

(1) It recognizes the importance of the problem of desertification and its priority with respect to other problems;

(2) It considers that the project in question is supplementary to other more direct means of combating desertification;

(3) There is no provision in the national plans for the financing of such a project.

77-2-0441-40

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 11/Rev.1

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77-2-0441-40

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 12

Proposal by the delegation of Honduras

The delegation of Costa Rica has submitted for consideration by this meeting a very sound proposal to change the term "desertificación" used up to now in the Spanish versions of resolutions and other documents of the United Nations by the word "desertización".

The delegation of Honduras, which supports the Costa Rican proposal, considers that the definition proposed for the word "desertification", in referring only to direct or indirect human action in diminishing or destroying normal biological production, is somewhat restrictive since it excludes other possible causes of desertification. The delegation of Honduras therefore proposes the following definition:

DESERTIFICATION: Reduction or elimination of biological production in any part of the globe.

77-2-0444-40

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 13

Observations by Dr. Guillermo Adriasola, representative of the International Planned Parenthood Federation, on the second preliminary draft of the Plan of Action to Combat Desertification

Chapter III-B - "Population and Health"

1. Observations

It is suggested that questions relating to population should be placed in a separate section from those relating to health, since each of these subjects is sufficiently important to warrant a separate section, their relations with aridity are very different, and the programmes for the control of such relations are also different.

Thus, the study of population dynamics shows that human communities are both causes and victims of aridity.

They generate aridity through:

- excessive or faulty extraction and consumption
- pollution
- destruction of ecosystems
- a host of other actions

all of which are aggravated by over-population.

Differences in levels of health, in contrast, do not affect aridity.

Aridity, for its part, causes migrations, changes in population structures, want and misery, but it is only a secondary cause of health problems.

2. Suggestions

2.1 If it is decided to deal with the relation between aridity and population in a separate section, this should enumerate the factors which produce or condition aridity and should describe the grounds for procedures designed to control such factors.

2.2 The section on Aridity and Health should include the appropriate public health recommendations.

77-2-0445-40

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Conference Room Paper Nº 14

Proposal submitted by the delegation of Costa Rica

With regard to the perusal, comments and proposed modifications of the document DESCONF/AMERICAS/2, "Plan of Action to Combat Desertification: Second preliminary draft" (item 5 of the provisional agenda of the Preparatory Meeting for the Americas), the delegation of Costa Rica considers it useful to propose:

1. That in the light of the strictest planning criteria, the whole document be reduced to a typical classified plan, in which only the broad lines universally valid for the various aspects of the problem of combatting desertification are sustained. Each concept sustained there should expressly or implicitly have the socio-economic and scientific content required by any component of a plan.

2. That all other concepts which are useful and not redundant be included, according to their nature, in two appendixes: one on programmes (indicating economic and technical resources, dates and places) and the other on projects (relating to specific activities in this field).

77-2-0454-40

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING
FOR THE AMERICAS

Convened by the Secretariat of the United Nations
Conference on Desertification in co-operation with
the Economic Commission for Latin America

Santiago, Chile, 23 - 26 February 1977

DRAFT REPORT

77-2-0401

CONTENTS

/Opening meeting

Opening meeting

1. The meeting was opened by the Executive Secretary of the Economic Commission for Latin America (CEPAL) who pointed out that in spite of possessing the world's greatest water resources, Latin America had four arid zones - northwest Mexico, northernmost South America, northeast Brazil and the great diagonal desert running from southwest Ecuador to southern Patagonia - as well as much land exposed to the risks of ecological damage and desertification. He said that the draft Plan of Action to Combat Desertification would be reviewed at the meeting, which should help to make it "of real significance for Latin America", and that CEPAL would be glad to undertake the tasks assigned to it by the Plan of Action as utlimately approved.

2. The Minister of Agriculture of Chile, General Mario Mackay Jaraquemada, welcomed the participants on behalf of the people and Government of Chile, a nation, he said, much concerned with the problems of its arid zones, which occupied 30 per cent of the country.

3. The Executive Director of the United Nations Environment Programme, in his capacity as Secretary-General of the Conference, outlined the problem of desertification as a global issue whose importance was brought home to the world by the 1967-1972 drought in the African Sahel. In the course of the preparations for the Conference consensus had been reached among the scientific community on various important points: that desertification was the result of the interaction of man and an adverse environment; that the process could be halted by the proper use of present knowledge, and that the key to the attack lay in proper land use. The Plan of Action therefore stressed the need for action now. With emphasis on correct land-use practices such as those endorsed by the scientific studies and investigations effected as part of the Conference preparations and all culminating in the Plan of Action. It was hoped that three things would emerge from the Regional Preparatory Meeting for the Americas: (i) an understanding of the region's own experience; (ii) the improvement that the region would like to see incorporated in the Plan of Action, and (iii) the views of Governments on the

/feasibility studies

feasibility studies in which they were participating. It was also hoped that this regional meeting would set a frank and constructive tone for those that followed.

Election of officers

4. The meeting elected the following Officers:
Chairman: Carlos Alberto Dulcic Belloni (Chile)
First Vice-Chairman: Alejandro Quesada Ramírez (Costa Rica)
Second Vice-Chairman: Dillard H. Gates (United States)
Rapporteur: Alberto Emilio Montbrun (Argentina)

Adoption of the agenda

5. The meeting adopted the Agenda reproduced in Annex 1.

Processes and causes of desertification (item 4 of the agenda)

6. The Conference documentation, reflecting an effort to assemble the available knowledge on desertification, was described. The subject had been divided into four aspects - climate, ecology, technology and population and society - each covered in reviews which would be available as background documents at the Conference. The four component reviews, prepared in Canada, Mexico, the United Kingdom and the United States, had been synthesized into Desertification: An Overview, one of the principal documents of the Conference and one which provided (a) a description of the causes and consequences of desertification and (b) justification for the recommendations in the Plan of Action. Contributions to the assembly of knowledge were made by scientists from all parts of the world and by specialists from throughout the United Nations family.

7. The Overview had access also to the Feasibility Studies and the Case Studies, with two of the latter carried out in the Region.

8. The findings of the Chilean Case Study, as presented, supported the conclusions of the Overview. The Coquimbo region, an area of cold-season rainfall, was shown to have suffered marked and constant deterioration for which man was a responsible agent. Declines in rainfall in this century indicated a pattern of recurrent droughts

/rather than

rather than a long-term climatic shift. Solutions to the area's problems must involve the local inhabitants, since social as well as physical questions were at issue. It was also found necessary to integrate solutions into general programmes of social and economic development.

9. The United States Case Study involved the rehabilitation of rangeland in a cold desert in southeastern Oregon, and the findings of this study, too, were consonant with the conclusions presented in the Overview: that resource degradation was a function of land use and not of climate change; that proper land management cost less than rehabilitation; that project success ultimately depended on the people who used the land; that social and political factors were as important as purely ecological factors; and that corrective action should begin on the basis of present knowledge and not wait for further research.

10. The Desertification Map of the World (1:25,000,000) prepared by FAO and UNESCO, and the Desertification Map of Africa North of the Equator (1:5,000,000) prepared by FAO were introduced. The Desertification Map of South America at a scale of 1:5,000,000 was presented with the explanation that in its present state the map represented a first approximation to be refined later. Areas which should be given closer study were indicated.

11. In introducing the document Desertification in Latin America with Regard to Ecology and Agriculture, the representative of the Inter-American Institute of Agricultural Sciences (IIAS) reviewed the general causes of desertification in Latin America and indicated the areas affected. The process could be halted or reversed by proper land use, water conservation and regeneration of plant cover in degraded areas: conclusions consonant with those in the Overview. Among his recommendations were the application of systems analysis and the development of mathematical models, the establishment of a regional centre for the protection and integrated development of arid areas, the establishment of an information and documentation

/centre linked

centre linked with the AGRIS and AGRINTER systems network which would work in close co-operation with the regional centre, and the organization of training programmes for Latin American technicians and scientists who worked in arid areas.

12. A suggestion that in Spanish, the term "desertificación" be replaced by "desertización" led to a distinction between the two terms in that language, the former being taken to refer to man's impact on ecosystems and the latter to natural processes.

13. The delegate of Honduras supported the foregoing proposal but suggested that "desertification" should be defined as "the reduction or elimination of biological production in any part of the globe".

14. The Costa Rican delegation presented a series of Conference Room Papers proposing: (a) that the meeting ask FAO to promote the exchange of biological packages between Andean and Himalayan experimental stations and agricultural extension centres; (b) that the meeting should recommend that the countries of the Americas take measures against overgrazing; (c) that the meeting suggest that FAO disseminate procedures to prevent or control the burning of vegetation, which promotes desertification; (d) that the meeting should recommend to governments that they enforce or modernize forest legislation to prevent uncontrolled deforestation, and (e) that the meeting recommend to Governments that they introduce or intensify the treatment or agricultural use of waste waters to reduce desertification caused by urbanization.

15. The suggestion that a regional centre be established was supported and reference was made to the possibility of using the Grupo Internacional para el Desarrollo Agropecuario para América Latina y el Caribe (GIDA/ALC) for that purpose.

16. Representatives of the Organization of American States (OAS), the Inter-American Development Bank (IDB), the United Nations Food and Agriculture Organization (FAO) and the United Nations Water Conference described their current and planned activities in the region. On the basis of these comments and those by other participants,

/it became

it became clear that there was general agreement on the following points: desertification was one of mankind's major problems; it was amenable to solution, but the process might accelerate before it was solved because of rising demands for increased food production; it was the result of improper land use, in which overgrazing by domestic animals was a major factor; case studies in arid zones of similar climate, e.g., Chile and Tunisia, should be looked at side by side and conclusions compared so that knowledge gained in one place could be used in others; sufficient knowledge was now available on desertification to begin action without awaiting further research, however valuable that research might probe to be; all campaigns against desertification should be carried out with the full understanding and co-operation of the local people involved; the social and political aspects of desertification were less well known that the physical aspects but were just as important in halting or reversing the process.

17. A summary of the feasibility studies on transnational co-operation to combat desertification was presented. The meeting was informed that official support had been given to the projects on the management of livestock in the Sudano-Sahel area, on the management of groundwater aquifers in northeast Africa and the Arabian peninsula, on the establishment of a Green Belt on the northern rim of the Sahara, and on the monitoring of desertification processes in southwest Asia. While awaiting official confirmation from Governments, the first steps toward implementation were being organized.

18. The discussion on the feasibility studies concentrated on the project proposed for Latin America - the monitoring of desertification and related natural resources in arid regions of South America. The representative of Peru supported the project. The representative of Argentina stated that the project was supplementary to other more direct means of combatting desertification. He said that his Government had not set aside any financing for the project, nor had it received any official information on the matter. The Argentine

/position was

position was supported by Chile. The United States delegation recognized that the information which could be obtained was of limited value and would have to be linked up by aerophotogrammetry. The representative of Bolivia requested that his Government be formally invited to participate in the project. The representative of Brazil submitted a statement saying that his Government was interested in the project and wished to be associated with it but felt that it could not at this stage be a participant since the ecology of Brazil's arid areas was so different from that of the arid areas of the other participating countries.

Draft Plan of Action to Combat Desertification (Item 5 of the Agenda)

19. The Plan of Action to Combat Desertification was introduced by the Conference Secretariat. It was agreed that the meeting would deal with the Plan chapter by chapter, suggesting changes, additions or deletions for the second preliminary draft in accordance with a regional perspective and the viewpoints of the delegates. Suggestions for changes were submitted in written form.

20. In the discussion of the Plan of Action, the following points were made: Recommendation 1 should be deleted since it gave the impression that action was impossible in the absence of complete planning and assessment. It was agreed that the desirability of planning and assessment should be stated somewhere in the Plan, possibly in Chapter F on strengthening indigenous science and technology, and would not appear as a recommendation. Since paragraph 36 stated that water was the main factor limiting productivity in the drylands, a statement would be added to the opening chapter pointing out that social and political structures were often among the factors limiting dryland productivity. It was suggested that great care must be taken in phrasing statements proposing se sedentarization of nomads, since sedentarization often gave rise to serious problems of desertification. Recommendation 6, it was noted, seemed to refer almost exclusively to pastoral nomadism, whereas the recommendation should be phrased so as to refer also

/to stock

to stock raising in semi-arid areas. It was proposed that specific references to the technical measures proposed in recommendations 8 and 9 be eliminated, since technical specialists would know what to do in specific situations of desertification. To this, the secretariat replied that the Plan of Action would be reviewed by many people other than technical specialists, and these people needed to be given some sense of what the problem involved.

21. It was further proposed that all recommendations relating to the human condition, such as population, family health and human settlements, should be collected together in one chapter, although it was recognized that such restructuring would not in any case be made until the reviews of the Plan of Action were completed.

22. It was suggested that Chapter G on supporting measures be deleted since it contained no substantive matters.

23. It was suggested that recommendations 14 and 15 be deleted on the grounds that existing United Nations machinery, such as, for example, the United Nations Development Programme, could carry out follow-up measures as required by the Plan of Action which the Conference approved.

24. The representative of the United Nations Water Conference extended greetings to the meeting from the Secretary-General of that Conference. He suggested that existing United Nations bodies capable of carrying out the various provisions of the Plan of Action should be named in the appropriate places in the next drafts. He presented a Conference Room Paper on links between the Water and Desertification Conferences.

25. Arrangements for the United Nations Conference on Desertification (Item 3 of the Agenda). A paper was presented to the meeting on arrangements for the Desertification Conference, to be held from 29 August to 9 September 1977 in Nairobi, Kenya. The Conference would be preceded by two days of informal consultations on procedural matters. As it would be a major United Nations Conference convened by the General Assembly, the report of the Conference would be submitted to the General Assembly at its next regular session.

/26. Provision

26. Provision had been made for the Conference to work as a Plenary and as a Committee of the Whole. The latter would be expected to handle the two substantive items on the agenda - Desertification: Its Causes and Consequences, and the Plan of Action to Combat Desertification.

27. Immediately following the Conference, a Workshop would be held for technical advisers to delegations and Governments to discuss what national action could best be taken to implement the Plan of Action adopted at the Conference.

28. Prior to the Conference, a symposium of non-governmental organizations having a scientific interest in desertification problems would discuss how selected topics in the Plan could involve action by private groups and scientific bodies. Also prior to the Conference, interested journalists would meet in an Encounter organized by the United Nations Centre for Economic and Social Information (CESI).

29. The suggestion was made that following the Conference, a meeting of Latin American experts should be convened to consider how best to carry out the provisions of the Plan of Action that were applicable to the region. In arranging such a meeting, the assistance of UNDP and CEPAL would be welcomed, as would that of the Secretary-General of the Conference.

30. Several other Conference Room Papers were submitted which made specific recommendations for appropriate action to deal with the problem of desertification. The Meeting decided that these papers would be grouped and transmitted to the Secretary-General of the Conference forthwith for consideration in his definitive submissions to the Conference.

/Annex 1

Annex 1

AGENDA

1. Election of officers

2. Adoption of the agenda.

3. Arrangements for the United Nations Conference on Desertification.

4. Processes and causes of desertification.

5. Draft plan of action to combat desertification.

6. Adoption of the report of the meeting.

Annex 2

LIST OF PARTICIPANTS

States Members of the United Nations

ARGENTINA

Representative: Gustavo A. van Gelderen

Members of Delegation: Eduardo Bustamante, Santos Goñi Marenco
Alberto Emilio Montbrun

BOLIVIA

Representative: Antonio Sainz Unzueta

BRAZIL

Representative: Luiz Felipe Teixeira Soares

CANADA

Representative: Michael F. Kergin

COLOMBIA

Representative: José María de Guzmán Noguera

COSTA RICA

Representative: Alejandro Quesada Ramírez

CHILE

Representative: Carlos Alberto Dulcic B.

Members of Delegation: Enrique Melkonian S., Fernando Silva, S., Sergio Bonilla B., Jenaro del Pozo P., Miguel Angel Capella S., Cristián Crempien L., Gonzalo Sepúlveda R., Juan Enrique Bernstein L., Fernando Squella, Mario Silva, Sergio Lailhacar, Mario Peralta P., Patricio Azócar, Mauricio Araya, Juan Gasto, Loreto Martín, Ernesto Hajek, Pedro Sutter L., Rómulo García T., Fernando Espinoza, Raúl Sánchez, Hugo Bodini, Pilar Cereceda, Luis Velozo, Rodolfo Walther, Carlos Correa, Gabriel Seisdedos.

ECUADOR

Representative: Manuel Granizo Romero

UNITED STATES

Representative: Dillard H. Gates

Members of Delegation: James H. Cheatham, Jack D. Johnson

FRANCE

Representative: René Dubois

GUATEMALA

Representative: Wiland Gundersen López

Member of Delegation: Hugo Abraham Orellana Paz

HAITI

Representative: Leonard Pierre-Louis

HONDURAS

Representative: Virgilio R. Gálvez Madrid

Member of Delegation: Ramón Benedetto Leiva

NETHERLANDS

Representative: Albert Van Der Struik

PANAMA

Representative: Ricardo Moreno Villalaz

PERU

Representative: Igor Velázquez Rodríguez

Member of Delegation: Carlos E. López-Ocaño

URUGUAY

Representative: Artigas Durán

States not members of the United Nations
attending on a consultative basis

SWITZERLAND

Representative: Fernando Vuffray

United Nations

United Nations Water Conference Secretariat
Centre for Natural Resources, Energy and Transport

Alagappa Alagappan

United Nations Development Programme (UNDP)

Eduardo F. Gutiérrez
Dietrich von Graevenitz

United Nations Industrial Development Organization (UNIDO)

Jack Carmichael

Specialized agencies

United Nations Food and Agriculture Organization (FAO)

Luis Santiago Botero
Mario A. Habit

United Nations Educational, Scientific and Cultural Organization (UNESCO)

Alberto Sireau

Intergovernmental organizations

Organization of American States (OAS)

Braulio Orejas-Miranda

Inter-American Development Bank (IDB)

Alberto A. Sojit
Yigal Harpaz

Inter-American Institute for Agricultural Sciences (IIAS)

Fernando Suárez de Castro
José Marull

Non-Governmental Organizations

International Council of Environmental Law (ICEL)

Rafael Valenzuela Fuenzalida

International Planned Parenthood Federation (IPPF)

Guillermo Adriasola E.

International Union for Conservation of Nature (IUCN)

Felipe Matos

Co-sponsors

United Nations Environment Programme (UNEP)

Mostafa K. Tolba

Secretariat of the United Nations Conference on Desertification

Ralph Townley

Manuel Anaya Garduno
Mohammed Kassas
Fernando Medellín-Leal
Virgilio Roig

Gaafar Karrar
Boris Rozanov
James Walls
Christopher Dunford

Economic Commission for Latin America (CEPAL)

Enrique V. Iglesias
Manuel Balboa
Jorge Viteri de la Huerta
Joseph El Haj
Eduardo García
Carlos Plaza
Daniel Blanchard
Marta Boeninger
Juana Eyzaguirre
Eugenio Lobo

Annex 3

LIST OF DOCUMENTS

Documents presented by the Conference Secretariat

Annotated Draft Provisional Agenda

Desertification: An Overview (First Draft)

Summaries and Abstracts of Desertification Case Studies

Current International Activities to Combat Desertification

Plan of Action to Combat Desertification (Second preliminary draft)

Plan of Action to Combat Desertification (Second preliminary draft). Corrigendum

Transnational Co-operation to Combat Desertification: Feasibility Studies

Transnational Co-operation to Combat Desertification: Feasibility Studies. Addendum 1

Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America: A Feasibility Study (An Abridgement)

Draft Report of the Second Meeting of the Panel on Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America (Lima, Peru, 17-19 February 1977)

Arrangements for the United Nations Conference on Desertification

Documents presented by Governments

Desertification in the United States (Jack D. Johnson, Office of Arid Lands Studies, University of Arizona for the United States Department of State)

Lucha contra la Desertificación: La experiencia de Chile (Estudio Nacional sobre la Desertificación presentado por Chile) *

El problema de la desertificación en la provincia de Manabí-Ecuador (Instituto Ecuatoriano de Recursos Hidraúlicos) *

Documento preliminar sobre la experiencia mexicana en el combate de la desertificación y el aprovechamiento de las zonas áridas *

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*/ Only in Spanish.

Documents presented by other organizations

Nota explicativa sobre el Mapa mundial de desertificación a una escala de 1:25 000 000 - United Nations Food and Agriculture Organization of the United Nations (FAO) *

La desertización en América Latina desde una perspectiva ecológica y agrícola (Fernando Suarez de Castro, Inter-American Institute for Agricultural Sciences (IIAS) - OAS)

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*/ Only in Spanish.

DESCONF/AMERICAS/10

UNITED NATIONS CONFERENCE ON DESERTIFICATION

REGIONAL PREPARATORY MEETING FOR THE AMERICAS

Convened by the Secretariat of the United Nations Conference on Desertification in co-operation with the Economic Commission for Latin America

Santiago, Chile, 23 - 25 February 1977

REPORT

77-3-0552

CONTENTS

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Rapporteur: Alberto Emilio Montbrun (Argentina)

Adoption of the agenda

5. The participants 1/ adopted the following Agenda for the Meeting:

1. Election of officers
2. Adoption of the agenda
3. Arrangements for the United Nations Conference on Desertification
4. Processes and causes of desertification
5. Draft plan of action to combat desertification
6. Adoption of the report of the Meeting

Processes and causes of desertification (Item 4 of the Agenda)

6. The Conference documentation, reflecting an effort to assemble the available knowledge on desertification, was described. The subject had been divided into four aspects - climate, ecology, technology and population and society - each covered in reviews which would be available as background documents at the Conference. The four component reviews, prepared in Canada, the United States, Mexico and the United Kingdom, had been synthesized into Desertification: An Overview, one of the principal documents of the Conference and one which provided (a) a description of the causes and consequences of desertification and (b) justification for the recommendations in the Plan of Action. Contributions to the assembly of knowledge were made by scientists from all parts of the world and by specialists from throughout the United Nations family.

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rainfall in this century indicated recurrent droughts rather than a long-term climatic shift. Solutions to the area's problems must involve the local inhabitants, since social as well as physical questions were at issue. It was also found necessary to integrate solutions into general programmes of social and economic development

9. The United States Case Study involved the rehabilitation of rangeland in a cold desert in southeastern Oregon, and the findings of this study, too, were consonant with the conclusions presented in the Overview: that resource degradation was a function of land use and not of climate change; that proper land management cost less than rehabilitation; that project success ultimately depended on the people who used the land; that social and political factors were as important as purely ecological factors; and that corrective action should begin on the basis of present knowledge and not wait for further research.

10. The Desertification Map of the World (1:25,000,000) prepared by FAO and UNESCO, and the Desertification Map of Africa North of the Equator (1:5,000,000) prepared by FAO were introduced. The Desertification Map of South America at a scale of 1:5,000,000 was presented with the explanation that in its present state the map represented a first approximation to be refined later. Areas which should be given closer study were indicated.

11. In introducing the document Desertification in Latin America with Regard to Ecology and Agriculture, the representative of the Inter-American Institute of Agricultural Sciences (IIAS) reviewed the general causes of desertification in Latin America and indicated the areas affected. The process could be halted or reversed by proper land use, water conservation and regeneration of plant cover in degraded areas. These conclusions were consonant with those in the Overview. Among his recommendations were the application of systems analysis and the development of mathematical models, the establishment of a regional centre for the protection and integrated development of arid areas, the establishment of an information and documentation

/centre linked

centre linked with the AGRIS and AGRINTER systems network which would work in close co-operation with the regional centre, and the organization of training programmes for Latin American technicians and scientists who worked in arid areas.

12. A suggestion that in Spanish, the term "desertificación" be replaced by "desertización" led to a distinction between the two terms in that language, the former being taken to refer to man's impact on ecosystems and the latter to natural processes.

13. The delegate of Honduras supported the foregoing proposal but suggested that "desertification" should be defined as "the reduction or elimination of biological production in any part of the globe".

14. The Costa Rican delegation presented a series of Conference Room Papers proposing: (a) that the Meeting ask FAO to promote the exchange of biological packages between Andean and Himalayan experimental stations and agricultural extension centres; (b) that the Meeting should recommend that the countries of the Americas take measures against overgrazing; (c) that the Meeting suggest that FAO disseminate procedures to prevent or control the burning of vegetation, which promotes desertification; (d) that the Meeting should recommend to governments that they enforce or modernize forest legislation to prevent uncontrolled deforestation, and (e) that the Meeting recommend to Governments that they introduce or intensify the treatment or agricultural use of waste waters to reduce desertification caused by urbanization.

15. The suggestion that a regional centre be established was supported and reference was made to the possibility of using the Grupo Internacional para el Desarrollo Agropecuario para América Latina y el Caribe (GIDA/ALC) for that purpose.

16. Representatives of the Organization of American States (OAS), the Inter-American Development Bank (IDB), the United Nations Food and Agriculture Organization (FAO) and the United Nations Water Conference and the Centre for Natural Resources, Energy and Transport (CNRET) described their current and planned activities in the region. On the basis of these comments and those by other participants,

/it became

it became clear that there was general agreement on the following points: desertification was one of mankind's major problems; it was amenable to solution, but the process might accelerate before it was solved because of rising demands for increased food production; it was the result of improper land use, in which overgrazing by domestic animals was a major factor; case studies in arid zones of similar climate, e.g., Chile and Tunisia, should be looked at side by side and conclusions compared so that knowledge gained in one place could be used in others; sufficient knowledge was now available on desertification to begin action without awaiting further research, however valuable that research might probe to be; all campaigns against desertification should be carried out with the full understanding and co-operation of the local people involved; the social and political aspects of desertification were less well known that the physical aspects but were just as important in halting or reversing the process.

17. A summary of the feasibility studies on transnational co-operation to combat desertification was presented. The Meeting was informed that official support had been given to the projects on the management of livestock in the Sudano-Sahel area, on the management of groundwater aquifers in northeast Africa and the Arabian peninsula, on the establishment of a Green Belt on the northern rim of the Sahara, and on the monitoring of desertification processes in southwest Asia. While awaiting official confirmation from Governments, the first steps toward implementation were being organized.

18. The discussion on the feasibility studies concentrated on the project proposed for Latin America - the monitoring of desertification and related natural resources in arid regions of South America. The representative of Peru supported the basic technical project. The representative of Argentina stated that the project was supplementary to other more direct means of combatting desertification. He said that his Government had not set aside any financing for the project, nor had it received any official information on the matter. The Argentine

/position was

position was supported by Chile. The United States delegation recognized that if the information obtained from satellite imagery was to be used for detailed planning then it would be useful if it were supplemented by air photography. The representative of Bolivia requested that his Government be formally invited to participate in the project. The representative of Brazil submitted a statement saying that his Government was interested in the project but felt that it could not at this stage be a participant since the ecology of Brazil's arid areas was so different from that of the arid areas of the other participating countries.

Draft Plan of Action to Combat Desertification (Item 5 of the Agenda)

19. The Plan of Action to Combat Desertification was introduced by the Conference Secretariat. It was agreed that the Meeting would deal with the Plan chapter by chapter, suggesting changes, additions or deletions for the second preliminary draft in accordance with a regional perspective and the viewpoints of the delegates. Suggestions for changes were submitted in written form.

20. In the discussion of the Plan of Action, the following points were made: Recommendation 1 should be deleted since it gave the impression that action was impossible in the absence of complete planning and assessment. It was agreed that the desirability of planning and assessment should be stated somewhere in the Plan, possibly in Chapter F on strengthening indigenous science and technology, and would not appear as an independent chapter. Since paragraph 36 stated that water was the main factor limiting productivity in the drylands, a statement would be added to the opening chapter pointing out that social and political structures were often among the factors limiting dryland productivity. It was suggested that great care must be taken in phrasing statements proposing sedentarization of nomands, since sedentarization often gave rise to serious problems of desertification.

21. Recommendation 6, it was noted, seemed to refer almost exclusively to pastoral nomadism, whereas the recommendation should be phrased so as to refer also to stock raising in semi-arid areas. The representative

/of Chile

of Chile noted that Recommendation 6 proposed the adoption of a series of measures to ameliorate degraded conditions in dryland pastures, to introduce improved systems of rangeland and livestock management and to improve the lot of desert pastoral communities. That would mean leaving out the pastoral communities of semi-arid areas, which were not necessarily characterized by the "traditional mobility" referred to in paragraph 40. Paragraph 41, for its part, listed a number of measures very much to the point which should be taken at the national level to put that recommendation into effect, but it was not pointed out that in order for these improved practices to be successful they must be incorporated in a system of production, and their application in an isolated manner could even make matters worse. It was therefore suggested that the following words should be inserted in paragraph 40 immediately after the first sentence: "The forest/agricultural ecosystem must be treated as a functional unit: it is therefore necessary to study, design and apply forestry, agricultural and stock-raising production systems which take account of their mutual connexions and inter-relations so as to give rise to economically and socially stable systems". The rest of paragraph 40, from "Regeneration" to "where required" would be deleted. The underlined Recommendation, for its part, would read as follows: "It is recommended that measures be taken to ameliorate degraded conditions in dryland pastures, to introduce improved systems of rangeland and livestock management, to develop integrated systems of production, and to improve the lot of pastoral communities". In paragraph 41 (e) it was suggested that a new sub-paragraph (ii) should be inserted, reading as follows: "Optimization of the use of dryland crop residues, agroindustrial waste and low-quality forage in general", with the existing sub-paragraphs (ii), (iii) and (iv) becoming (iii), (iv) and (v) respectively. In paragraph 41 (g) it was proposed that the words "and improved land tenure systems" should be inserted between "planned land use" and "supported by ...". Finally, it was suggested that in paragraph 42 (c) sub-paragraph (ii) should be amended to read: "determining the optimum size of agricultural units in accordance with the carrying capacity of their grazing land".

/22. It

22. It was proposed that specific references to the technical measures proposed in recommendations 8 and 9 be eliminated, since technical specialists would know what to do in specific situations of desertification. To this, the secretariat replied that the Plan of Action would be reviewed by many people other than technical specialists, and these people needed to be given some sense of what the problem involved.

23. With regard to Recommendation 10 on Alternative Energy Sources, the representative of Brazil proposed that the following sentence should be added at the end of paragraph 55: "Investigations should also be carried out, if judged advisable by the Governments concerned, into other energy sources which could solve the energy problems of the drylands", while in the underlined part of the Recommendation itself the words "that will yield simple, inexpensive and useful devices to serve the needs of dryland peoples" should be deleted and replaced by the words "that will enable the energy needs of those areas to be satisfied". In paragraph 56 (a) the words "simple and efficient" should be deleted, while a third sub-paragraph (c) should be added at the end of the paragraph, reading: "Take such other measures to solve the energy problems of the drylands as are considered advisable by Governments". Finally, the words "simple, inexpensive and convenient" should be deleted from the fifth line of paragraph 55.

24. The participants noted that the Conference on Technical Co-operation among Developing Countries, sponsored by UNDP, was to be held in Argentina from 27 March to 7 April 1978, and the seventeenth session of CEPAL, to be held in Guatemala from 25 April to 5 May 1977, would also include that subject in its agenda. In view of that, the Meeting supported the recommendations on technical co-operation among developing countries in matters concerning desertification and assinged the highest importance to regional co-operation in that and other spheres and to the strengthening of regional and national institutions.

/25. It

25. It was further proposed that all recommendations relating to the human condition, such as population, family health and human settlements, should be collected together in one chapter, although it was recognized that such restructuring would not in any case be made until the reviews of the Plan of Action were completed.

26. It was suggested that Chapter G on supporting measures be deleted on the grounds that it contained no substantive matters, unless it included a codified and updated listing of the legal enactments on the conservation of natural resources.

27. It was suggested that recommendations 14 and 15 be deleted because existing national, international and United Nations machinery could carry out follow-up measures as required by the Plan of Action approved by the Conference.

28. The representative of the United Nations Water Conference extended greetings to the Meeting from the Secretary-General of that Conference. He suggested that existing United Nations bodies capable of carrying out the various provisions of the Plan of Action should be named in the appropriate places in the respective drafts. He presented a Conference Room Paper on links between the Water and Desertification Conferences.

Arrangements for the United Nations Conference on Desertification (Item 3 of the Agenda)

29. A paper was presented to the Meeting on arrangements for the Desertification Conference, to be held from 29 August to 9 September 1977 in Nairobi, Kenya. The Conference would be preceded by two days of informal consultations on procedural matters. As it would be a major United Nations Conference convened by the General Assembly, the report of the Conference would be submitted to the General Assembly at its next regular session.

/30. Provision

30. Provision had been made for the Conference to work as a Plenary and as a Committee of the Whole. The latter would be expected to handle the two substantive items on the agenda - Desertification: Its Causes and Consequences, and the Plan of Action to Combat Desertification.

31. Immediately following the Conference, a Workshop would be held for technical advisers to delegations to discuss what national action could best be taken to implement the Plan of Action adopted at the Conference.

32. Prior to the Conference, a symposium of non-governmental organizations having a scientific interest in desertification problems would discuss how selected topics in the Plan could involve action by private groups and scientific bodies. Also prior to the Conference, interested journalists would meet in an Encounter organized by the United Nations Centre for Economic and Social Information (CESI).

33. The suggestion was made that following the Conference, a meeting of Latin American experts should be convened to consider how best to carry out the provisions of the Plan of Action that were applicable to the region. In arranging such a meeting, the assistance of UNDP and CEPAL would be welcomed, as would that of the Secretary-General of the Conference.

34. Several other Conference Room Papers were submitted which made specific recommendations for appropriate action to deal with the problem of desertification. The Meeting decided that these papers would be grouped and transmitted to the Secretary-General of the Conference forthwith for consideration in his definitive submissions to the Conference.

/Adoption of

Adoption of the report of the Meeting (Item 6 of the Agenda)

35. The present report was approved at the final meeting, held at 6.30 p.m. on Friday 25 February.

36. The Executive Secretary of CEPAL stated that because the Regional Preparatory Meeting for the Americas, which was the first of the Preparatory Meetings for the United Nations Desertification Conference, had been organized rather hastily, some of the participating Governments had not received the documents and proposals from the Secretary-General of the Conference sufficiently in advance. Furthermore, not all the member countries of CEPAL had participated in the Meeting. Consequently, any comments on the subjects covered in the Meeting which interested Governments might wish to submit to the secretariat of CEPAL before 31 March 1977 would be distributed as Annexes to the present report.

Closing meeting

37. At the closing meeting, statements were made by Mr. Enrique V. Iglesias, Executive Secretary of CEPAL; by Mr. Ralph Townley, Director of the Secretariat of the United Nations Desertification Conference, on behalf of the Secretary-General of the Conference; and by the Chairman of the Meeting. All stressed the importance of the work done and thanked participants for their valuable contribution to the enrichment of knowledge on the subjects discussed.

/Annex 1

Annex 1

LIST OF PARTICIPANTS

States Members of the United Nations

ARGENTINA

Representative: Gustavo A. van Gelderen

Members of Delegation: Eduardo Bustamante, Santos Goñi Marenco
Alberto Emilio Montbrun

BOLIVIA

Representative: Antonio Sainz Unzueta

BRAZIL

Representative: Luiz Felipe Teixeira Soares

CANADA

Representative: Michael F. Kergin

COLOMBIA

Representative: José María de Guzmán Noguera

COSTA RICA

Representative: Alejandro Quesada Ramírez

CHILE

Representative: Carlos Alberto Dulcic B.

Members of Delegation: Mauricio Araya, Patricio Azócar, Juan Enrique Bernstein L., Hugo Bodini, Sergio Bonilla B., Miguel Angel Capella S., Pilar Cereceda, Cristián Crempien L., Carlos Correa, Jenaro del Pozo P., Fernando Espinoza, Rómulo García T., Juan Gasto, Ernesto Hajek, Sergio Lailhacar, Loreto Martín, Enrique Molkonian,S., Mario Peralta P., Raúl Sánchez, Gabriel Seisdedos, Gonzalo Sepúlveda R., Mario Silva, Fernando Silva S., Fernando Squella, Pedro Sutter L., Luis Velozo, Rodolfo Walther.

ECUADOR

Representative: Manuel Granizo Romero

UNITED STATES

Representative: Dillard H. Gates

Members of Delegation: James H. Cheatham, Jack D. Johnson

FRANCE

Representative: René Dubois

GUATEMALA

Representative: Wiland Gundersen López

Member of Delegation: Hugo Abraham Orellana Paz

HAITI

Representative: Leonard Pierre-Louis

HONDURAS

Representative: Virgilio R. Gálvez Madrid

Member of Delegation: Ramón Benedetto Leiva

NETHERLANDS

Representative: Albert Van Der Struik

PANAMA

Representative: Ricardo Moreno Villalaz

PERU

Representative: Igor Velázquez Rodríguez

Member of Delegation: Carlos E. López-Ocaño

URUGUAY

Representative: Artigas Durán

States not members of the United Nations attending in a consultative capacity

SWITZERLAND

Representative: Fernando Vuffray

United Nations

United Nations Water Conference Secretariat
Centre for Natural Resources, Energy and Transport

Alagappa Alagappan

United Nations Development Programme (UNDP)

Eduardo F. Gutiérrez
Dietrich von Graevenitz

United Nations Industrial Development Organization (UNIDO)

Jack Carmichael

Specialized agencies

United Nations Food and Agriculture Organization (FAO)

Luis Santiago Botero
Mario A. Habit

United Nations Educational, Scientific and Cultural Organization (UNESCO)

Alberto Sireau

Intergovernmental organizations

Organization of American States (OAS)

Braulio Orejas-Miranda

Inter-American Development Bank (IDB)

Alberto A. Sojit
Yigal Harpaz

Inter-American Institute for Agricultural Sciences (IIAS)

Fernando Suárez de Castro
José Marull

Non-governmental organizations

International Council of Environmental Law (ICEL)

Rafael Valenzuela Fuenzalida

International Planned Parenthood Federation (IPPF)

Guillermo Adriasola E.

International Union for the Conservation of Nature (IUCN)

Felipe Matos

Co-sponsors

United Nations Environment Programme (UNEP)

Mostafa K. Tolba

Secretariat of the United Nations Conference on Desertification

Ralph Townley

Manuel Anaya Garduno
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Fernando Medellín-Leal
Virgilio Roig

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Economic Commission for Latin America (CEPAL)

Enrique V. Iglesias
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Jorge Viteri de la Huerta
Joseph El Haj
Eduardo García
Carlos Plaza
Daniel Blanchard
Marta Boeninger
Juana Eyzaguirre
Eugenio Lobo

Annex 2

LIST OF DOCUMENTS

Documents presented by the Conference Secretariat

Annotated Draft Provisional Agenda

Desertification: An Overview (First Draft)

Summaries and Abstracts of Desertification Case Studies

Current International Activities to Combat Desertification

Plan of Action to Combat Desertification (Second preliminary draft)

Plan of Action to Combat Desertification (Second preliminary draft). Corrigendum

Transnational Co-operation to Combat Desertification: Feasibility Studies

Transnational Co-operation to Combat Desertification: Feasibility Studies. Addendum 1

Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America: A Feasibility Study (An Abridgement)

Draft Report of the Second Meeting of the Panel on Monitoring Desertification Processes and Related Natural Resources in Critical Areas of South America (Lima, Peru, 17-19 February 1977)

Arrangements for the United Nations Conference on Desertification

Documents presented by Governments

Desertification in the United States (Jack D. Johnson, Office of Arid Lands Studies, University of Arizona for the United States Department of State)

Lucha contra la Desertificación: La experiencia de Chile (Estudio Nacional sobre la Desertificación presentado por Chile) *

El problema de la desertificación en la provincia de Manabí-Ecuador (Instituto Ecuatoriano de Recursos Hidraúlicos) *

Documento preliminar sobre la experiencia mexicana en el combate de la desertificación y el aprovechamiento de las zonas áridas *

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*/ Only in Spanish.

Documents presented by other organizations

Nota explicativa sobre el Mapa mundial de desertificación a una escala de 1:25 000 000 - United Nations Food and Agriculture Organization of the United Nations (FAO) */

La desertización en América Latina desde una perspectiva ecológica y agrícola (Fernando Suarez de Castro, Inter-American Institute for Agricultural Sciences (IIAS) - OAS)

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*/ Only in Spanish.