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Desertification Control Bulletin

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

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Introduction of new method of irrigation to extend the land under cultivation. Lodar area in Yemen, UNEP/AGFUND project. Photo: UNEP.

Cover: Terraces have formed naturally above soil conservation hedges. Photo: ICRAF

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

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

Immediately after approval of the PACD, the Desertification Unit was established within UNEP to assist the Executive Director and ACC in carrying out their tasks to implement it.

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

One of the main functions required by the PACD from the Desertification Unit is to prepare, compile, edit and publish at six-monthly intervals a bulletin to disseminate information on, and knowledge of, desertification problems and to present news on the programmes, activities and achievements in the implementation of the PACD around the world. Articles published in *Desertification Control Bulletin* do not imply expression of any opinion on the part of UNEP concerning the legal status of any country, territory, city or area, or its authorities, or concerning the delimitation of its frontiers or boundaries.

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Cover

Photographs

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

Technical requirements

Photographs must be colour transparencies of subjects related directly to desertification, land, animals, human beings, structures affected by desertification, control of desertification, reclamation of desertified lands, etc. Submissions must be of high quality to be enlarged to accommodate a square 18 cm x 18 cm (8 in x 8 in).

Captions

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

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Articles

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

Audience

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

Language

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

Manuscript preparation

Manuscripts should be clearly typewritten with double spacing and wide margins, on one side of the page only. The title of the manuscript, with the author's name and address, should be given in the upper half of the first page and the number of words in the main text should appear in the upper right corner. Subsequent pages should have only the author's name in the upper right hand corner. Users of word-processors are welcome to submit their articles on diskette in MS-DOS format, indicating the programme used.

Metric system

All measurements should be in the metric system.

Tables

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

Illustrations and photographs

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

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

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

Footnotes and references

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

Other requirements

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

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Inter-Governmental Negotiating Committee for the Convention on Combating Desertification [1]

1 - This report was compiled from the opening address of the Executive Secretary of the INCD, Ambassador Hama Arba Diallo, and the Chairman, Ambassador Bo Kjellén at the first Substantive Session of the INDC in Nairobi from 24 May to June 1993, together with information from volume 4, issue 2 of *Earth Negotiations Bulletin.*

A Brief History

The Intergovernmental Negotiating Committee for the elaboration of an international convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa is a product of the UN Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992. Although the idea of a convention to combat desertification had been discussed earlier in the UNCED preparatory process, it was only in Rio where language was adopted requesting the UN General Assembly to establish an intergovernmental committee (INCD) for the purpose of negotiating the convention.

The hope is that the convention will marshall commitments and cooperation at all levels to implement a new approach to combating desertification and mitigating drought by promoting sustainable development at the local community level and, simultaneously, managing land resources sustainably to maximize dryland productivity.

This is the first environmental convention to be negotiated after the UNCED Conference in Rio. Consequently INCD's work will have an important bearing on the deliberations of the Commission on Sustainable Development and more generally on the promotion of a partnership for sustainable development worldwide. The negotiating process offers to the international community a unique opportunity to initiate a timely change towards a brighter future in the countries affected by recurring droughts and desertification.

Organisational Session

The organisational session of the INCD was held from 26-29 January 1993 at UN headquarters in New York. The purpose of the session was to adopt the rules of procedure and the schedule of meetings, elect the officers of the INCD, establish the two working groups, agree on the agenda for the first substantive session (see below), and discuss the financial aspects of the process. At the meeting Ambassador Bo Kjellén of Sweden was elected Chair of the Committee and Ambassadors René Valéry Mongbe (Benin), T.P. Sreenivasan (India) and José Urrutia (Peru) were elected to the Bureau.

Schedule of Meetings

The organisational session adopted the schedule for the five meetings of the INCD. The first substantive session was held in Nairobi in May (see below) with subsequent sessions to be held from 13-24 September in Geneva, 17-28 January 1994 in New York and 21-31 March 1994 in Geneva. The final session, where the convention will be adopted, will be held in Paris from.

Working Groups

During the organisational session, it was also decided that the INCD would establish two working groups. These working groups met for the first time during the second substantive session in September 1993 and each working group has a three-person bureau.

Funds

General Assembly Resolution 47/188 also established two special funds for the INCD. The first is a trust fund for the operation of the secretariat and the second is a voluntary fund designed to facilitate the participation of developing countries in the process. Sweden, France, the Netherlands, Spain, the US, Germany, Norway, Japan, the UK, Canada and Denmark announced plans to contribute to one or both of these funds.

International Panel of Experts on Desertification

Paragraph 12 of Resolution 47/188 established a multidisciplinary International Panel of Experts on Desertification (IPED) to assist the Secretariat and, under its authority, to provide the necessary expertise in the scientific, technical, legal and other related fields. The IPED consists of approximately 15 scientists drawn from all regions of the world and from a wide variety of scientific disciplines, including climatology, soil science, pastoral systems, agro-forestry, geographical information systems, biodiversity, water resource management, historical geography, dryland ecology, land resource planning, alternative energy systems, socio-economics, water conservation and protection of cultural resources. The IPED held an organisational meeting in February in Geneva. It then met again in Geneva from 1-3 April to help prepare a paper on the Format and Elements of the Convention and in August to help the Secretariat assemble documents incorporating all the elements proposed for the convention by various governments, agencies and the OAU. The IPED will continue to meet roughly six weeks before each INCD negotiating session.

Inter-Agency Coordination Group

The Secretariat also convened the Inter-agency Coordination Group - a working group of representatives from UN agencies concerned with drought and desertification problems. The ICG will offer recommendations to the Secretariat on the possible elements of the convention and will coordinate with them fully to ensure their full involvement in the negotiating process. This group meets immediately after the IPED sessions to review the Panel's work with the Secretariat, and on other occasions as the need arises. A representative of NGOs will attend future meetings of the Inter-agency Coordination Group as an observer.

Non-Governmental Organisations

Paragraph 19 of Resolution 47/188 invited all relevant Non-Governmental Organisations (NGOs) and especially encouraged NGOs from developing countries to contribute constructively to the success of the negotiating process. The rules of procedure for NGO participation mirror those of the UNCED process.

The Secretariat is working closely with NGOs through a contact group which held its first meeting in Geneva from 7-8 April. The contact group had already previously organised a number of activities, including workshops, and made a presentation during the first week of the first Substantive Session of the INCD in Nairobi. A seminar attended by NGOs from all around the world, was held in August in Bamako, Mali.

African Experts Group Meeting

During the first week of May a group of African Experts met in Nairobi under the aegis of the Organisation of African Unity, following the recommendations made by the Conference of Ministers of the OAU states. Its objective was to initiate a process through which the governments could identify common elements in the Convention.

The Chairman Ambassador Bo Kjellén addressing the first session of the INCD at UN Headquarters, Nairobi accompanied by Robert Ryan (centre) Special Advisor to the INCD Secretariat and Franklin Cardy (left) Deputy Assistant Executive Director, UNEP, 24 May 1993. Photo: UNEP.

As a result of this meeting, a six-member OAU Working Group on Desertification was formed to provide technical information for African delegates during the substantive sessions of the Committee. The African Experts Group will issue a report of its meeting as well as reports prepared by two working groups on African views and perspectives on global elements of the Convention, and specific problems faced by Africa as a result of desertification and drought.

Case Studies

The organisational session of the INCD called on the Secretariat to organise a series of case studies to develop flexible models of:

a the commitments which individual countries affected could take to combat desertification and mitigate drought through local, national and sub-regional policies and programmes, and

b the commitments of the international community in support of these policies and programmes.

The case studies will evolve general guidelines for action on long-term programmes but would not provide the type of model which would be replicable in detail in all situations.

Four African countries (Botswana, Mali, Tunisia and Uganda), and four organisations in the sub-regions (Comite Inter-Arabe pour La Lutte Contre la Secheresse en le Sahel [CILSS], Inter-Governmental Authority Against Drought and Desertification [IGADD], Southern African Development Coordination Conference (SADCC) and Arab Maghreb Union (AMB) are conducting the first stage of the case studies. Other countries and sub-regions outside Africa will be addressed later as funding becomes available.

First Substantive Session

The first Substantive Session of the INCD was held at the UN complex in Nairobi from 24 May to 3 June 1993.

Some 86 governments, plus the Palestine Liberation Organisation and the African National Congress, eight UN organisations, 10 inter-governmental organisations and 47 NGOs took part in the session. The first week was devoted to the topic of *Sharing of Technical Information and Assessments*, which included seven sub-topics:

1 desertification, drought and the global environment:
2 causes, general extent and consequences of land degradation in arid, semi-arid and dry sub-humid areas:
3 social and economic dimensions:
4 patterns of bilateral and multilateral assistance programmes:
5 experience with international, regional, sub-regional and national programmes to combat desertification and mitigate drought in developing countries:
6 experiences of developed countries, and
7 some possible elements of a new

strategy to promote development in countries experiencing drought and desertification.

During the second week the format and possible elements of the convention were discussed, including principles, definitions and objectives. Other convention elements have been divided into National and Sub-regional Action Programmes; Global Commitments; Institutional Arrangements; and Procedural Arrangements. These were to be further elaborated and discussed in the next sessions of the INCD in September 1993, and January and March 1994. If the convention is to be agreed and signed in Paris in June 1994 as scheduled, all parties have a considerable amount of work before them to meet the deadline.

Information Sharing at the First INCD Meeting

The presentations and exchanges of views at the initial session were very well attended and considered very helpful to the process. In deciding on this innovation in a UN convention the General Assembly provided an extraordinary opportunity to assess the measure of the global character of the drylands problem.

During the week it became clear that there are still serious gaps in the information available and a great need for improved access to it and appropriate mechanisms for its dissemination. This is true in several key areas such as basic science and research, as well as monitoring systems, but also with regard to the results achieved in desertification control so far - the failures and the success stories. The Secretariat hopes to compile all this into one document.

The linkages between desertification and other issues of global concern were clarified. The link between desertification and global warming, including effects such as the increase of dust in the atmosphere, changes in albedo and others were discussed. The relations between climate change, biodiversity and desertification were reviewed and discussed and some elements highlighted.

Grass Roots Participation

A leading theme in practically all the presentations was the need for real, effective participation at the village level. This appears today to be a crucial issue in achieving successful action and credible programme implementation. The social and cultural aspects of local communities and the respect for local conditions and customs have to be taken into account both in the formulation of programmes and in the drafting of legislation. Particular attention was given to legislation on land tenure, which might require increased attention and new approaches by the international community. The particularly important role of women and the need to have them fully involved was also highlighted.

It has been seen that both modern and traditional technologies can provide adequate solutions and that there is a need to improve its exchange among countries and regions to disseminate the most positive experiences. Provisions should be made to ensure that this really happens.

Research programmes have to be strengthened in order to provide a basis for sound action; and dissemination methods have to be given particular attention.

Perspectives for Negotiation

The INCD is part of a global, long-term effort to change unsustainable trends; an effort designed to turn the combination of environment and development into a reality for everybody. As Principle One of the Rio Declaration so proudly proclaims:

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

No-one is so naive as to believe that this is the case today. Television screens throughout the world show horror stories of the reality 24 hours a day as Ambassador Bo Kjellèn, the Chairman of the INCD pointed out " *unacceptable abject poverty is at close range. And yet, as Confucius put it, 'it is better to light a little candle than just to damn the darkness'. Or, as the American poet Carl Sandburg wrote: 'The republic was a dream. Nothing happens unless first a dream'* "."

"The 1977 UN Conference on Desertification and the Plan of Action to Combat Desertification constitute a major effort by the international community and recognition is due to all the people who are dedicated to, and involved in this work. UNEP's experience and support, particularly that of the Executive Director, Elizabeth Dowdeswell, and the Director of DC/PAC, Franklin Cardy, must also be recognised. UNEP will continue to play a central role in the struggle against desertification and the Plan of Action Against Desertification may be incorporated into any new structure that will emerge from the negotiations."

"If there is one message that came out loud and clear from the last few days of the INCD meeting it was the *need for local participation and the need to listen carefully to the demands and view points of the people in the villages*. It is well known that this is not an easy thing; beyond the rhetoric many conflicts of interest appear, local situations are very different and traditional systems of governance clash with modern government structures, all of which create a web of complexities."

"But there is no way around the obvious fact that the women and men most concerned are those who must have a decisive influence on matters that are essential to their own living conditions. But they also have the right to receive the best possible information on long-term options; and they need to have the necessary support to implement such long-term options when present hardships make it very difficult to see beyond the next crop. All this requires technical and financial resources well geared to the needs."

DC/PAC exhibition

During the INCD meeting in Nairobi, DC/PAC organised an exhibition on desertification at the UN complex in which nine governments (Australia, Finland, Iran, Israel, New Zealand, Tunisia and the USA) eight NGOs, the International Council for Research on agroforestry and six UN organisations (UNEP, FAO, IFAD, UNDP/UNSO, UNESCO and WMO) participated.

A Brief Analysis of the Second Session of INCD 13 - 24 September 1993

While the first session of the INCD provided the context and set the tone for the series of negotiating sessions to follow, it was the second session where the work of elaborating a convention to combat desertification actually began. During this two-week session, delegates progressed from stating their initial positions to clarifying areas of convergence and divergence.

In Nairobi, delegates reached agreement on the nature and structure of the Convention. They also requested the Secretariat to compile the various substantive suggestions and proposals presented by governments into a single compilation text. It was this text that served as the basis for negotiations at the second session. During the two weeks of discussion of this compilation text by the two working groups in Geneva, governments continued to state their initial positions on the various sections of the Convention. Further areas of convergence and divergence began to emerge.

The discussions on the compilation text were characterized by a sense of cooperation and a desire to make progress. Most delegations arrived at the second session with clearly defined positions and specific suggestions to enable the Secretariat to prepare a draft of the Convention for the next session. The Organization of African Unity had prepared specific drafting suggestions for each section of the Convention. Many other delegations proposed that certain sections of the OAU draft should serve as the basis for further negotiation. As a result of this positive atmosphere and the high level of preparation, the Working Groups were able to complete a full reading of the compilation text and set in motion the process that will enable delegates to begin actual negotiations in New York.

Already, there appears to be consensus on a number of specific items. Working Group I agreed on the need for: a clear and concise preamble that refers to the history of desertification in the UN system; clear and concise objectives; commitments that are central to the Convention and articulated at different levels (local, regional and international); and for these commitments to be clear, specific, and implementable. National action programmes should be forward-looking, long-term, and contain provisions for regular review, assessment and adjustment. Individual countries should determine what is necessary for their own national plans and local populations should be involved in the development of national plans.

In the section on sub-regional action programmes, there was consensus that sub-regional programmes should complement national programmes, strengthen national capabilities, and increase the cooperation between them. All delegates supported the need to address capacity building, and many stressed that capacity building is the cornerstone of the Convention. Most delegates saw a need for a public awareness strategy and improved education on drought and desertification at all levels. Many delegates stressed the need for increased cooperation and coordination between North and South, South and South, among bilateral and multilateral donors.

In its discussion on research and development, Working Group II agreed on the use of local knowledge and experiences and a bottom-up approach. There was also agreement on the need for early warning systems; accessibility of information; and the need to identify information needs at the local, national and sub-regional levels. On the issue of transfer of technology and cooperation, there was consensus on: the need too involve the private sector and governments; the use of existing institutions for technology transfer, the need for training; additional finances to ensure accessibility; the need for culturally-relevant technology; and the need to guard against dumping. Delegates agreed to defer substantive discussion on institutions and procedural matters until agreement is reached on the nature of the convention and the issue of regional instruments. Nevertheless, some converging views did in fact emerge. These included: the necessity of the Conference of Parties and the Secretariat; the requirement for at least 30 ratifications for the convention to enter into force; and the recommendation that the convention should be signed at the Heads of State level.

The two areas that provoked the widest divergence of views were financial resources and mechanisms and regional instruments. Although there appeared to be agreement on the need for improved donor coordination and more effective utilization of existing funds, disagreement prevailed in a number of areas. These include: new and additional resources; establishment of a special fund; a new window in the GEF to fund desertification; and mandating the contribution of 0.7% of GNP for development assistance. Certain delegates appeared to have changed their positions since the Nairobi meeting. In Nairobi, many more developing countries had called for a new window in the GEF, whereas in Geneva the emphasis seemed to shift away from the GEF and towards the establishment of a special fund.

In Nairobi, the most difficult issue of the session was the preparation of regional instruments and the future work of the Committee. However, unlike Nairobi, the G-77 was able to meet and agree on a common position. The formula that facilitated G-77 agreement ensured that the Convention and the regional instrument for Africa would be finalized by June 1994 and proposed scheduling a meeting during the interim period pending the entry into force of the Convention to review the situation regarding other regional instruments, thus allowing all necessary regional instruments to enter into force with the Convention.

At this point, however, difficulties developed between the G-77 and the Western Europe and Others Group (WEOG) over one major issue: the "global" nature of desertification. Some developed country delegates felt that the term "global" had specific connotations within the Climate Change Convention. In this regard, the responsibility of developed countries had been established and certain obligations assumed. At the INCD, developed countries wanted to avoid any possible linkages that would alter the nature of future assistance, making it, in essence, an obligation. In addition, some delegates felt that by using the word "global" it would allow for a claim to be laid to access GEF funds for combating desertification.

Despite this problem, most delegates left Geneva with a feeling of optimism. A great deal of progress had been made during the two-week session. As a result, the Convention is clearly beginning to take shape.

The Plenary at its closing session on 24 September adopted the draft provisional agenda for the third session (17-28 January 1994, New York). The agenda includes: adoption of the organization of work; the elaboration of an international convention to combat desertification in countries experiencing serious drought and/or desertification, particularly in Africa; review of the situation regarding extra-budgetary funds; the adoption of a provisional agenda for the fourth session; and the adoption of the report of the Committee on its third session.

Agricultural Sustainability and Soil Resilience

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Introduction

The origin of all living things on earth can be linked, directly or indirectly, to soil. Soil resources of the world are finite in geographical extent. Only 11% of the earth's total land area of 13.4 x 10^9ha is currently being cultivated. The remaining potentially cultivable land is marginal for agricultural use because most of it is either inaccessible or is severely constrained by unfavorably steep terrain, shallow rooting depth, extremes of moisture and/or temperature regimes, shortages of essential inputs, or is located in ecologically sensitive regions.

The per capita arable land area of 0.3 ha in 1990 is expected to decrease to 0.25 ha in the year 2000, 0.15 ha in the year 2050 and about 0.10 ha in the year 2150. Human needs, with per capita arable land area of 0.10 ha, can only be met with the assistance of science-based and innovative technology. Consequently, there is an overwhelming interest in instigating sustainable land use systems that prevent or minimize soil degradation and restore productive capacity and life support processes of degraded lands.

Agricultural sustainability and *soil degradation* are complex concepts with subjective values. What these concepts are understood to mean varies according to the user's immediate and longterm concerns and needs. The scientific community needs to develop objective, consistent and operational definitions of both *agricultural sustainability* and *soil degradation* which can then by used to create a rational and science-based strategy for resource management. The objective is to have practical and operational ways to achieve agricultural sustainability and to prevent soil degradation and thereby to alleviate the pressing problems of modern agriculture. In other words, to increase per capita productivity and decrease the risks of soil and environmental degradation. In this context, agricultural sustainability means 'an increasing trend in per capita productivity per unit consumption of the non-renewable or the limiting resource, or per unit degradation of soil and environmental characteristics or per unit reduction in soil's life support processes'. The aim is not only to increase per capita productivity but also to maximize production per unit of soil loss, per unit of energy input, per unit of reduction in soil organic carbon, per unit of efflux or radiatively active gases, per unit of consumption of ground water and per unit of increase in concentration of NO_3, $P0_4$ or other pollutants in natural waters.

Soil Resilience

Soil is a dynamic entity, and dynamism is life. Because early civilizations originated and flourished on fertile soils, many ancient cultures developed reverence for the soil on which they depended. They believed that humans originated from the land and that land is a living entity worthy of worship. For example, the Maori of New Zealand believe that 'the land is a mother that never dies'. These beliefs are similar to the modern 'Gaia Hypothesis' that proposes that 'earth is a living organism' and 'is a complex entity involving the biosphere, atmosphere, oceans and soil; the totality constituting a feedback or cybernetic system which seeks an optimal physical and chemical environment for life' (Lovelock, 1979).

Soil dynamism is evidenced by continuous formative and evolutionary changes until a dynamic equilibrium is achieved. Anthropogenic perturbations alter this state of equilibrium and may change the rate and direction of principal processes (Rozanov, 1990). With the advent of modern technology, human actions are becoming progressively drastic due to the development of bigger and faster machines, and concentrated and highly active chemicals designed to enhance soil fertility and accentuate plant growth. The greater the human demands, the more potent are the technologies likely to have drastic effects on soil processes.

The 'Magic of Mother Earth' is her ability to heal herself and the term 'soil resilience' refers to the soil's ability to bounce or spring back into shape or position after being stressed. As a dynamic and an organic entity, soil has an in-built ability to restore its life-support processes, provided that the disturbance created by human intervention is not too drastic and sufficient time is allowed for the recovery processes to take effect. However, soil can undergo irreversible degradation if it is drastically disturbed and its life support processes are severely jeopardized. Through constant misuse and mismanagement 'man may sap the vitality of Gaia by reducing productivity and by deleting key species in her life-support systems' (Lovelock, 1979). Soil resilience can, therefore, also be defined as the ability of soil to restore its life-support processes after it has been degraded by natural or human-induced perturbations. Soil resilience depends on balance between soil restorative and soil degradative processes. It is a function of the harmonious and symbiotic action of all living organisms in that it creates favourable environments for life to thrive. Although humans value only crops and livestock, other unwanted species are not necessarily pests, weeds or vermin - they too play an important role in the self-regulatory mechanisms of Mother Earth (Lovelock, 1979).

Soil resilience depends on close interrelationships between soil degradative and soil restorative processes, and the factors and processes that influence their magnitude and direction. Soil degradative processes are set in motion when the soil structure starts to deteriorate, the carbon cycles are disrupted, nutrient reserves within the soil are depleted and nutrient recycling mechanisms are weakened. Soil restorative or self-regulatory processes are strengthened by science-based agriculture, discriminate and judicious land use, reduction of pressure on marginal lands and fragile ecosystems, and adoption of improved technology.

Rate of New Soil Formation

Soil is a renewable resource as long as the balance between the rate of soil formation and soil degradation is positive, otherwise it is a non-renewable entity - at least within a human lifetime. The time frame is an important consideration in this analysis. Most available data are based on informed opinion and indirect evaluation and vary enormously. Some estimates put the rate of soil formation at about 2.5 cm (1 inch) in a thousand years. However, Friend (1992) estimated that worldwide the rate of soil formation is about 2.5 cm (or 1 inch) per 150 years. In general, soils of volcanic origin develop faster than those developed on gneiss or basement complex rocks. The rate of new soil formation for Andisols in the humid tropics is <1 mm/year. In contrast, the rate of new soil formation for Alfisols and Ultisols is <0.01 mm/year. Under normal conditions, however, new soil is formed at the rate of about 2.5 cm (1 inch) in 300 to 1,000 years. It would seem, therefore, that most soils are non-renewable within a human life span. The major exception to this rule is the formation of alluvial flood plains by rivers carrying heavy sediment loads, such as the Yellow River, the Ganges, etc.

Soil Degradation Rate

Soil degradation, or the decline in a soil's capacity to produce goods of value to humans, has plagued the earth ever since human exploitation of land began. Many ancient civilizations thrived on 'good soil' and declined as soils became degraded through misuse. Typical examples are the Riparian and Harappan Kalibangan culture in the Indus Valley, Mesopotamian and Lydian Kingdoms in the Mediterranean region, and the Mayan civilization in Central America. These great civilizations declined along with depletion of the original mantle of fertile topsoil. The problem of soil degradation has been drastically accentuated by changes in land use since the 18th century. It is estimated that out of the world's total land area of 13.4 x 10^9ha, about 2.0 x 10^9ha is degraded to some degree (World Resources Institute, 1992-1993). Asia and Africa combined account for a total of 1.24 x 10^9ha of degraded land. There are several processes of soil degradation. Most prominent among these are wind and water erosion, chemical degradation and fertility depletion, and physical degradation resulting from decline in soil structure. Estimates of soil degradation in dry climates are equally alarming. Such statistics play an important role in creating awareness about the magnitude and severity of the problem and in formulating a global strategy in addressing it. Indeed, if these statistics are correct, soil degradation presents one of the greatest challenges to the human race because soil resources are finite and, to all intent, may be considered non-renewable. Even though the statistics can only be approximately correct, it should be a matter of the greatest urgency for decision-makers and opinion-shapers to do something about the problem.

However, careful analyses of these data on land/soil degradation reveal several problems. First, there may be a problem with the statistics themselves. As explained earlier, the term 'soil degradation' is vague and highly subjective: to avoid ambiguity, it is important that soil degradation by different processes be defined quantitatively. To do so is to delineate threshold values or critical limits of soil properties beyond which soil's life support processes are severely jeopardized. The important soil properties for which critical limits need to be defined are rooting depth, plant-available water capacity, soil organic matter content, soil structural attributes, capacity and intensity factors and limiting levels of principal nutrients. These limits vary among soils, climatic conditions, farming systems, land uses and managerial inputs.

Second, there is a problem even with this data since ignorance about the critical limits and threshold values of soil properties often makes global data vague and unreliable.

Third, soil degradation and productivity must be considered in relation to land use, inputs and management using improved technology. The World Map of the Status of Human-Induced Soil Degradation (GLASOD) project by ISRIC/UNEP (1990) and FAO's (1991) map of soil resources are steps in the right direction and the information provided can lead to the development of cause-effect relationships between soil degradation and agronomic productivity.

Inputs and Improved Technology

It is true that the majority of soils in ecologically sensitive regions have undergone drastic changes in their properties due to intensive cultivation, land misuse and other anthropogenic perturbations. However, the impact of these changes on productive potential has not been determined. The productivity of degraded soils can be greatly enhanced by improved management and proper land use. Soil degradation must, therefore, be determined scientifically according to its degree and the processes affecting it so that improved management and judicious land use can be implemented to set in motion the restorative processes, even on drastically disturbed lands.

Improved technology reduced soil erosion and degradation on crop land in the USA, according to measurements made by Lee (1990). Using similar erosion survey techniques, Lee observed that sheet and rill erosion from crop land in USA declined by 11.5% between 1982 and 1987 thanks to conservation management improvements. In the Conservation Reserve Program authorized in the Food Security Act of 1985, the adoption of conservation-effective technology reduced soil erosion in the USA by about 0.5 billion tons (or roughly one third) in its first five years from 1986 to 1991. The projected reduction for a 10-year period from 1986-1995 is estimated at about 60%. This dramatic reduction in soil erosion in the USA is not only a major success story but also an example of how improved technology can assist natural soil resilience to restore soil productivity and prevent further soil degradation.

Wolman (1967) developed a schematics of sequence of land use changes in the USA with sediment yield over a period of two centuries from 1800 to the year 2000. As the forests were cleared and cultivated, grasslands ploughed and construction activity increased, so did the sediment yield. However, adoption of conservation practices reduced sediment yield for the same land use system. This pattern of sediment yield in relation to landuse and conservation technology was similar for all soils, except that the amplitude of change differed depending on soil properties, terrain characteristics and the climatic environment. In addition to benefits in crop yield, scientific management can also set in motion soil restorative processes. Vast areas of land that were once the 'dust bowl' of the south-central USA have been transformed into highly productive lands by science-based agriculture. Similarly, vast areas of salt-crusted, barren lands in Haryana and Punjab provinces in India have been transformed into highly productive lands by science-based improved land use systems.

Agriculture in North America, Western Europe and other developed economies has undergone several phases of development. Per capita productivity has drastically increased with each phase, beginning with human power, moving on to horse power, improvements in farm implements, use of motorized equipment and chemical fertilizers and pesticides, and use of improved and input-responsive varieties of crops. These technological innovations have been used most successfully on undegraded, naturally-resilient, prime agricultural land. Similar innovations need to be developed for soils degraded by different processes since improved technology and appropriate land use vary according to the processes of soil degradation and the extent to which they have progressed.

Endogenous Factors	Exogenous Factors
1 Rooting depth	1 Land use and farming system
2 Soil texture and clay mineralogy	2 Technological innovations
3 Parent material	3 Inputs and management
4 Landscape and terrain	
5 Moisture regime	
6 Micro- and meso-climate	
7 Soil biodiversity, eg, flora and fauna	

Table 1: Factors affecting soil resilience (Lal, 1992b)

Time Scale

The issue of time scale is highly pertinent. Soil may be a renewable resource over the geological time scale but not over the human life span. However, with increasing demographic pressure, issues of productivity and sustainability must be addressed over the human life span, if not over the even shorter, common economic-planning time span. In fact, there is tremendous pressure to produce needed goods and services over the economic-planning time span of five to 10 years, or less. Therefore, it is appropriate to test the impact of innovative technologies on soil restoration or resilience over the human or scientific time span of 20 to 25 years. As was previously explained, with the exception of volcanic soils and some aeolian and alluvial deposits, the amount of new soil formation over the scientific and human time span may be small, if not negligible, in real terms.

Factors Affecting Soil Resilience

There are a multitude of interacting factors that affect soil resilience. These factors can be broadly grouped into two categories: (a) endogenous, and (b) exogenous (table 1). Endogenous factors are related to inherent soil properties and micro- and meso-climate.

Factors that enhance soil resilience are sufficient rooting depth, loam to clay-loam texture, structurally-active soils containing high activity clay minerals, a high proportion of stable micro-aggregates, gentle to rolling terrain, good internal drainage and a favorable micro-climate.

High soil organic matter content and other characteristics of fertile soil depend on these conditions. There are several examples of such highly productive soils, eg, alluvial soils along major rivers, Mollisols, Inceptisols, Andisols and soils formed on highly basic parent materials. Because of their high inherent nutrient levels and favorable soil physical properties, these soils are remarkable resilient even with poor or lax management. Life support processes of such soils can withstand some degree of mistreatment and neglect without being seriously harmed or suffering lasting deleterious effects.

Land use, soil, crop and livestock management are important exogenous factors. The choice of an appropriate use for the land and the adoption of science-based, improved technology play a major role in restoring soil productivity. Together they can enhance and sustain high productivity and accentuate the resilience of even fragile soils in ecologically sensitive regions. Improved scientific technology also acts synergistically with prime agricultural lands to improve soil resilience. And adopting an appropriate land use and implementing science-based, improved technology are particularly crucial to sustainable use and resilience of soils which have either been degraded due to past misuse, or which have

Rotation Treatment	Plow-till from 1973-79			No-till from 1973-79*		
	1979	1984	% Change	1979	1984	% Change
Maize-maize	10.5	7.1	-32.3	10.2	07.8	-23.5
Maize-pigeon pea	10.2	4.7	-53.9	15.6	04.2	-73.0
Maize-mucuna	09.0	4.6	-18.0	19.2	07.3	-61.9
Maize-leucaena	04.2	6.4	+52.3	16.2	16.6	+02.5
Natural fallow	07.2	6.5	-09.7	06.0	07.8	+30.0

* No-till system was adopted from 1974 to 1984 in all treatments

Table 2: Restorative effects of crop rotations and agroforestry systems on infiltration rate of an eroded Alfisol in western Nigeria (IITA, Block D; Lal, 1992b)

inherent constraints, such as shallow depth, steep terrain or high erodibility, etc.

The important effect of science-based inputs, judicious land use and adoption of modern technology on soil resilience becomes evident when comparing soil erosion data from the USA in the 1930s and in the 1980s. Estimates of soil erosion by Bennet (1939) showed that half of the USA land area had been affected by erosion before and during the 1930s. In addition to 40 million ha of essentially ruined crop land, the process of soil erosion had already damaged or was threatening to damage more than one-third of the arable land. Approximately 75% of USA crop land in the 1930s was susceptible to some degree of erosion.

Bennet (1939) also observed that the lack of increase in yields of corn and cotton for the 60-year period from 1971 to 1930 was due to the impact of severe soil erosion. However, estimates of soil erosion 50 years later showed that the extent and magnitude of soil erosion were drastically less in 1989 than in 1939. Technological advances and use of energy inputs apparently resulted in high production without excessively stressing these resources.

Miller *et al* (1985) observed that much of the 'ruined' land described by Bennet in the 1930s was used for producing timber and forages in the 1980s and 1990s. The 'ruined' land of the 1930s had been restored, at least partially, to be agronomically productive and environmentally safe in that it contributed less sediments to the ocean, waterways, lakes and reservoirs.

Land Use, Soil Management and Sustainability

Evaluating land capability, adopting an appropriate land use and employing farming systems and soil and crop management practices that realize the potential of the land and restore its productivity are important considerations in long range planning for effective development and sustainable use of land resources. Scientific management of any land use is just as, if not more, important than the land use itself. In the context of soil degradation and restoration, 'how' to use the land is as important as 'what' to use it for. Furthermore, the amount and quality of biomass produced depends on the efficiency, magnitude and total flux of (i) nutrients (ii) water, and (iii) energy through the soil-plant-management system since these govern productivity and sustainability.

Soil Structure and Sustainability

Soil structure management is crucial to soil resilience and agricultural sustainability. Although it is a complex attribute that is difficult to characterize and quantify, soil structure regulates the fluvial and transport pathways, and circulatory and respiratory processes of soil. It regulates fluid retention and movement, nutrient transformations and translocation, faunal activity and species diversity, and the strength and rigidity of rooting media.

For most soils, the maintenance and enhancement of soil structure depend on land use. Land use systems that enhance soil structure are those practices that optimize (which for most soils means increase) soil organic matter content, and the activity and species diversity of macro- and meso-fauna. These systems include mulch farming, conservation

Treatment	Cultivation Duration (years)								
	Pre-clearing 1978	1	2	3	4	5	6	7	8
Continuous cropping (watershed 4)	146.0	30.6	28.2	12.6	12.6	20.4	13.8	10.2	10.8
Traditional cropping (watershed 7)	156.0	46.8	37.8	19.8*	19.2	24.0	43.2	115.8	193.0

*Reverted to natural fallow

Table 3: Restorative effects of natural fallowing on infiltration rate (cm/hr) of an Alfisol (Lal, 1992a)

Rotation Treatment	Plow-till from 1973-79		No-till from 1973-79	
	1982	% increase over 1979	1982	% increase over 1979
Maize-maize	1.10	7.8	1.30	0.0
Maize-pigeon pea	1.50	47.1	1.41	8.5
Maize-mucuna	1.40	37.3	1.48	13.8
Maize-Leucaena	1.22	19.6	1.34	3.0
Natural fallow	1.30	27.5	1.46	12.3

Initial level of organic carbon in 1979
Plow-till = 1.02%
No-till = 1.30%

Table 4: Restorative effects of crop rotations on soil organic carbon content (%) for 0-10 cm depth of an eroded Alfisol in western Nigeria (Block D, IITA: Lal, 1992b)

tillage, frequent use of planted fallows and cover crops, appropriate rotations and crop sequences and combinations, etc.

Through the judicious use of organic manures and inorganic fertilizers, nutrient management and soil fertility improvement also play an important role in improving the soil structure.

Soil Erosion Management

Soil erosion control is crucial to the sustainable management of soil resources and to soil resilience. In some cases, taking the pressures off marginal lands is probably the best solution for controlling accelerated erosion. In other cases, intensive cultivation of prime agricultural land, creating off-farm employment and developing income-generating capabilities in non-agricultural sectors can be important options.

When science-based, intensive agriculture is limited to prime agricultural land, there are several options for erosion management. The choice of an appropriate option should be carefully made with due consideration to soil types, land form and terrain characteristics, rainfall regime and hydrology, cropping/farming systems and socio-economic factors.

Farming Systems and Erosion Control

Conservation effective measures are those that enhance soil structure, decrease raindrop impact, improve infiltration capacity and decrease runoff rate and amount. These techniques are judicious systems of soil and crop management and include practices such as no-till or conservation-tillage, mulch farming through cover crops and planted fallows, multiple cropping and multi-storey canopy including agro-forestry.

Several longterm soil restorative experiments were conducted at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The data from these experiments are shown in tables 2 to 4. It seems that the growing of deep-rooted shrubs or woody perennials is crucial to improving the infiltration rate and restoring the structure of a severely degraded soil with compacted sub-soil. The data in table 2 show that improvements in the infiltration rate were brought about only by growing *Leucaena leucocephala*. In this severely eroded soil, a natural fallow period of about five years was not effective in restoring soil structure. However, bush fallowing can improve infiltration rate and soil structure if the soil is not severely degraded. For example, the data in table 3 show gradual improvements over time in the infiltration rate after the land reverted to bush fallow. The data in table 4 show that an increase in organic carbon content of the surface layer was achieved by growing annual/seasonal cover crops that produce large amounts of biomass, eg *Mucuna utilis*. Woody shrubs or deep-rooted perennials were not as effective in producing a large quantity of biomass as aggressively grown cover crops.

Residue Management and Erosion Control

A regular and sizable addition of organic material is essential to maintain a favorable level of soil organic matter content and to stimulate biotic activity of soil fauna, eg earthworms and termites. Structural collapse of soils with predominantly low-activity clays can be avoided by maintaining high organic matter content (about 2% soil organic carbon content) and by enhancing the activity of soil fauna. Crop residue mulch is an important ingredient of any improved farming/cropping system. Frequent applications of 4-5 t/ha of residue mulch applied to the soil surface is beneficial for soil and water conservation, regulating soil moisture and temperature regimes, improving soil structure, enhancing the biological activity of soil fauna, and protecting soils from high intensity rains and from ultra-desiccation. Mulching also suppresses weed growth.

While the beneficial effects of mulching are widely recognized, economic procurement of mulch material in sufficient quantities is a serious practical problem. Management of crop residue as a source of mulch is, therefore, closely linked with the cropping system, tillage methods and planted fallows. A range of cultural practices are available to procure adequate amounts of residue mulch for soil protection and fertility enhancement, eg, cover crops, conservation tillage, sod seeding, agroforestry, etc. Live mulch, alley cropping, ley farming, planted fallows and the use of industrial by-products are some of the cultural practices specifically adopted to procure mulch. Once again, suitability of a practice depends on the local-specific, biophysical and socio-economic environment.

Plant	Soil	Water
1. Biomass production	1. Soil structure	1. Water balance
2. Productivity	2. Net rate of soil renewal	2. Water quality
3. Nutritive quality	3. Nutrient fluxes & cycling	3. Water:air ratio in the root zone
4. Soil organic matter content		
	5. Rooting depth	
	6. Gaseous fluxes	

Table 5: Some indices of sustainability for plant, soil and water resources (Lal, 1992b)

Crop Management and Erosion Control

A continuous ground cover is necessary to provide a buffer against sudden fluctuations in micro- and mesoclimate, and to prevent the degradative effects of raindrop impact or high velocity winds. Timely planting, use of viable seed at optimum rates, use of improved cultivars and cropping systems, correct fertilizer use and pest management are all important aspects of good farming practices. The benefits of timely planting include the provision of a buffer against uncertain rains, unfavourable soil temperature regimes, pest infestation and unfavorable markets. Planted fallows, both legume and grass covers, are generally more effective in restoring soil fertility and improving soil physical properties than natural fallows. Soil organic matter can often be increased and soil structure improved over a short period of two to three years.

There are several methods of managing cover crops. Live mulch is a system of growing grain/food crops through a low-canopy cover crop. Mixed cropping creates diversity and decreases soil erosion risks. Agroforestry and mixed farming are also important techniques to create diversity. Mixed farming can be a stable system for small land holders provided that pastures are lightly grazed, the stocking rate is low and animal waste is applied to the land to replenish soil fertility. Whether this system is economic or not will depend on price structures. Economic circumstances can force farmers to adopt some practices. Mixed farming with excessive stocking rates and uncontrolled grazing is usually unsuccessful and degrades the soil and the environment, as is the case in the African Sahel.

Energy Management

The overall energy input and output must be regulated to enhance the output:input ratio and to attain a positive thermodynamic energy balance with respect to biological yield vs production inputs. Both energy efficiency and flux must be increased. A low output subsistence system can be highly efficient in terms of energy use but is unsuitable because of low productivity. However, the energy of a high-input system can be improved by reducing nutrient losses by effectively containing leaching and erosion, and enhancing nutrient capital through judicious inputs of chemical fertilizers and organic or other amendments (liming). Nitrogen deficiency is a major constraint in most soils of the tropics and subtropics. Local-specific research is needed to ensure an adequate supply of nitrogen for the desired level of economic yields through the input of synthetic fertilizers, wherever these can be economically used, supplemented by alternative sources of nitrogen, eg, symbiotic nitrogen fixation through legume-based rotations and agroforestry systems, organic manures and composts, and azolla, etc.

Similarly, productivity of soils notably deficient in available phosphates can only be enhanced through substantial and regular additions of phosphatic fertilizers.

The efficiency of fertilizer use can no doubt be increased by the use of new cultivars and through mycorrhizal infection.

Since the use of synthetic fertilizers is inevitable, the strategy is to decrease the rate of application through better systems of soil and crop management. Plant nutrients depleted through harvesting and other losses must be replenished. The source of nutrients, organic or inorganic, is not crucial as long as nutrients are supplied in adequate quantity and in a readily-available form. However, hoping to increase and sustain agricultural production by adding chemicals alone, without improved and efficient systems of soil and crop management, is bound to cause frustrations and disappointments. It is the judicious combination of both management and inputs that is crucial to a sustainable use of natural resources.

Technological Options for Sustainable Land Use

A truly sustainable land use system meets the following criteria:

- a it enhances soil resilience through longterm maintenance of biological and ecological integrity of natural resources;
- b it sustains a desirable level of support to the social, political and economic well being of a farm, community or regions, and
- c it enhances quality of life.

In the context of agriculture, sustainability of a land use system can be assessed by evaluating characteristics of plant, soil and water resources (table 5). The system is sustainable if:

- i a favourable level of soil structure is maintained;
- ii soil erosion is controlled;
- iii nutrients are effectively recycled;
- iv soil organic matter content is optimized, and
- v water and energy regimes are maintained favorable to the ecological integrity of the system.

The basic principles of sustainable use of soil and water resources are the same for all ecoregions. However, technological options may be soil and site specific. Some basic principles and underlying technological options for sustainable use of soil and water resources for the humid and sub-humid/semi-arid tropical regions are outlined in tables 6 and 7 respectively. Judicious use of these options is likely to sustain productivity and life support systems of soil and water resources.

Conclusions

Soil, the essence of all life on earth, is a non-renewable and a finite resource. The rise and fall of ancient civilizations depended in part on the quality and managerial ability of occupants to maintain and enhance life support processes of soil resources. The judicious use through discriminate and objective management of the eternal trinity of soil, water and climate is as crucial to human survival and welfare now as it was for the extinct civilizations who could not manage these most basic of all resources. The sustainability of soil resources must be assessed in terms of trends in per capita productivity with reference to changes in soil properties, water characteristics and climatic factors.

The rate of soil depletion and degradation of soil productivity depend on land use and soil management, and may be independent of profile depth for soils with root-restrictive, sub-soil characteristics. Choice of appropriate land use and use of science-based, improved technology can enhance and sustain soil productivity and accentuate resilience of even fragile soils in ecologically sensitive ecoregions.

Science-based land use, (how it is used rather than what it is used for) is important to sustainability and resilience. There are also important policy issues involved in sustainable land use. The principal processes involved in soil resilience are:

- i control of soil organic matter content;
- ii improvement in soil structure;
- iii increase in soil biodiversity;
- iv reduction in soil degradation and erosion rates below the soil formation rate, and
- v increase in nutrient capital and recycling mechanisms.

The basic technological principles to achieve these are known and include practices of good farming, eg, conservation tillage, mulch farming, crop rotations involving cover crops and planted fallows, mixed farming with controlled grazing and low stocking rate, agroforestry, and use of inorganic fertilizers and organic manures. Above all, it is important to use improved crops and cultivars, and to introduce new crops and species with the potential to develop into agro-based industries. More specifically, a long term research programme is needed with the following objectives:

- i To standardize criteria, delineate threshold values of soil properties,

Arable Land Use

1 Use prime land and avoid steep and shallow slopes.
2 Forest removal by manual methods, or by shearblade.
3 Use cover crop and mulch farming techniques for soil and water conservation.
4 Frequent use of planted fallows is necessary.
5 Wherever feasible, integrate woody perennials and livestock food crop annuals.

Pasture Development

1 Use prime land and avoid steep/shallow slopes.
2 Proper clearing methods are essential, eg, manual, slash and burn, etc. Tree defoliants can also be used in regions with low tree density. Dead trees can be left standing.
3 Seeding with suitable and ecologically adapted mixture of grass and legumes is necessary.
4 Maintain soil fertility as per soil test values. Balanced fertilization is important.
5 Stocking rate should be low. Controlled and rotational grazing should be adopted.
6 Use live fences and vegetative hedges.

Agroforestry

1 Use prime land of high inherent fertility.
2 Land should be cleared by manual methods or shearblade.
3 Choice of native tree species which do not aggressively compete with annuals is critical.
4 Proper tree management is crucial.
5 Choice of appropriate crops and cropping sequences is critical.
6 Soil fertility should be managed in relation to cropping intensity and soil test values.

Forest Plantations

1 Use prime land with no severe limitations.
2 Clear existing vegetation by manual methods, slash and burn or shearblade. Some roots and stumps can be left intact.
3 Seed a leguminous cover crop immediately.
4 Establish tree seedlings through the leguminous cover by suppressing it through chemical or mechanical means. Cover crop management is crucial to tree establishment.
5 Use balanced fertilizer based on soil test value and tree requirement.
6 Use effective soil and water conservation techniques.

Table 6: Best management practices for sustainable land use in humid tropics (Lal, 1992b)

and develop quantitative and reliable methods of assessment of soil degradation by different processes at the local, regional and global scale. There is a need to improve the reliability and accuracy of statistics on soil degradation.

ii To develop objective and quantifiable criteria of soil resilience and assess resilience of major soils in relation to parent material, soil properties, land use and management systems.

iii To develop appropriate land uses and restorative measures for enhancing economic productivity of degraded soils. Assessing accurately the extent of soil degradation, establishing the cause-effect relationship, choosing appropriate land use and developing restorative measures are important research and development priorities. However, it is also important to identify what land is restorable and for what use.

iv To identify the reasons why farmers do not accept available research information.

v To evaluate soil dynamics and evolution under different land uses and farming systems for principal soils and ecoregions.

vi To increase per capita productivity per unit input of non-renewable resources and per unit decline in important soil properties, and

viii To develop an index of agricultural sustainability and soil resilience. To be functional, the sustainability and resilience concepts must be based on quantitative indices.

Water Conservation

- Rough seedbed, deep plowing at the end of rains.
- Tied ridges.
- Micro-catchments.
- Use broadbed and furrow system in Vertisols.
- Supplementary irrigation where needed.
- Use wind breaks of leguminous shrubs and trees
- Reduce weed competition

Soil Fertility Management

- Apply farm yard manure, organic wastes, and nitrogenous fertilizers.
- Apply micro-nutrients where needed.
- Turn under as much crop residue and biomass as possible.
- Increase fertilizer use efficiency through water conservation, split dose application and placement in the vicinity of row zone.
- Use cover crops and green manures.

Crop Management

- Improved crops and cultivars developed/adapted for harsh environment.
- Multiple cropping based on inter-cropping, ration cropping, relay cropping and mixed cropping systems.
- Use agroforestry systems based on native tree species where appropriate.
- Use ley farming based on growing appropriate forages, light/controlled grazing, and relevant cropping sequences.
- Improve crop stand through use of good seed, high seed rate, appropriate seeding equipment.
- Seed in furrow to minimize sand blasting and decrease the adverse effects of high soil temperature.

Table 7: Best management practices for sustainable land use in semi-arid and arid tropics (Lal, 1992b)

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Salt-affected Soils as the Ecosystem for Halophytes

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Soils and Ecosystems

It is generally accepted that the soil is a substantial part of the environment comprising different substances which in themselves form a special kind of ecosystem inside the given ecosystem, with various properties and attributes. It is also accepted that the soil of the continents is of great diversity and is consequently dealt with by different branches of soil science, eg, classification, survey, mapping, etc.

The soil, or the pedosphere, which is an environmental synonym for the soils of a given territory, has a specific place in Nature. It is a natural body, similar to rocks, waters or biota in that they, too, have their own materials, mass and energy fluxes, development and regularities. This fact should be mentioned because, both in general and in technical literature, soils are frequently treated either as living substances or as non-biological substances. Neither of these approaches is correct, because one of the characteristics of the soil is its complexity - the fact that it contains both living and non-living substances, and is formed through both biotic and abiotic processes.

On the one hand, the soil as a natural body is inseparable from the rocks and the crust of weathering on the surface of the continents from which it has developed. On the other hand, it is also inseparable from biological processes. The main characteristic that distinguishes soil from rocks is the result of biological processes: the production of organic matters by the activities of micro-organisms, plants, invertebrates and other animals, including human activities. These transform the rocks into soils, capable of supplying plants and crops with nutrients and water.

The processes of soil formation started concurrently with the appearance of life on the continents. It continued during the billions of years of interaction between living substances and rocks and, over time, was influenced by climatic conditions, in particular the action of water, and geomorphological patterns. As a result of the interaction of specific mass and energy fluxes, different soil types were formed in different environmental conditions.

With the appearance of the human race on earth even different environmental changes took place. Due to human activities, the natural processes affected by biotic and abiotic factors accelerated and several other processes, which were unknown or minimal before, developed.

The role of soils in Nature is complex and many-sided and includes biospheric, hydrospheric and lithospheric functions. Their interaction is illustrated in figure 1. This clearly shows that the soil is a specific body in relation to the ecosystem. Even the word "soil" is very often used as a synonym of an ecosystem when the given ecological conditions in a certain place are being characterized. More precisely though, it must be said that the soil (or *pedon*) is actually a part of the ecosystem. However, soil has different states (solid, liquid, gaseous), living and non-living substances, plants, animals, microbes and has its own energy and material fluxes. So it can also be considered an ecosystem in itself. In this respect, when speaking of soils versus their plant cover, we can consider the soils of a given place as the basis, larder and foothold for the ecosystem developing on the spot. It is well known that close correlations exist between soil type and soil properties, and the plant cover developing on it. For instance, it is generally accepted that in savannas or in the tropical belt a well-defined plant cover develops and very often the soil properties promote or limit the living conditions of certain plant species or associations.

Based upon these considerations it can be accepted that when certain soil types are discussed as the habitat for certain plant associations, they are often named as the ecosystem of the plant association concerned as, besides the plants, the pedon includes most of the components of the ecosystem.

As a specific natural entity, the soil is evidently far from being identical to the vegetation and, in spite of their close correlation, direct conversion between soil types and vegetation is hardly possible. Still, there are soil types which more or less determine the ecological function for certain types of vegetation, either by providing beneficial conditions for their development or by limiting the ecological conditions for other types of vegetation.

This is perhaps best demonstrated in the case of salt-affected soils where high electrolyte contents or extreme pH conditions limit the development of the majority of plants and serve as a habitat only for those species that can survive or tolerate the unfavourable conditions caused by the salinity and alkalinity of the soil. In such respects, salt-affected soils can be considered as the habitat or ecosystem for halophytes and, if we agree on this, correlations can be found between the different types of salt-affected soils and their flora and fauna as components of the ecosystem.

In order to clarify both the theoretical and practical aspects of such considerations, it is necessary to describe briefly the properties and grouping of salt-affected soils with regard to the possible occurrences and distribution of halophytes and xerophytes developing on them. Nearly 10% of the land surface of the world is covered with different types of salt-affected soils. Table 1 (page 16) demonstrates their distribution.

Salt-Affected Soils - their Development and Grouping

Although the properties and attributes of salt-affected soils have been well-known for some time, it is useful to give a brief definition of this group of soils right at the start since the salinity, alkalinity and acidity of soils are substantial stress factors on land productivity.

Salt-affected soils can be characterized as formations that are predominantly influenced by different salts in their solid or liquid states, which eventually will also have a decisive influence on the development, characteristics, physical, chemical and biological properties and eventually the fertility of the soil. Whenever and wherever this phenomenon occurs, it produces specific formations of soils where the high electrolyte concentration and its consequences overshadow the former soil-forming processes or former soil properties and environmental conditions, often radically changing them (figure 2).

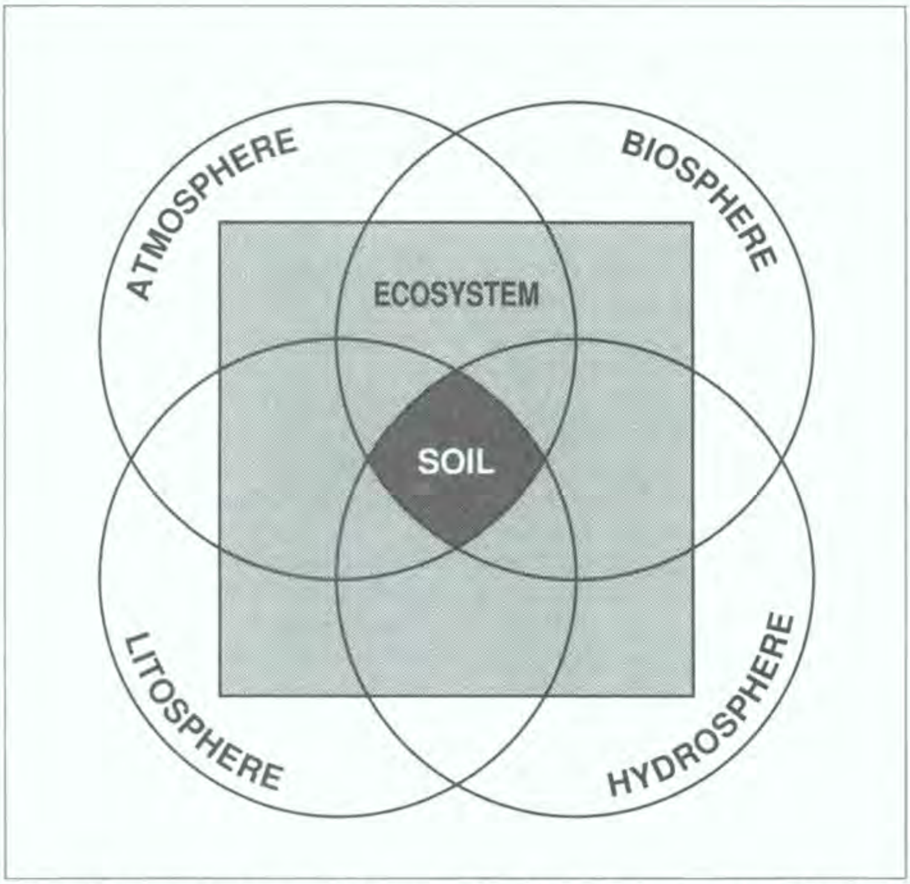

Figure 1: Schematic diagram of the interaction of lithosphere, atmosphere, biosphere, hydrosphere, ecosystems and soils (Szabolcs, 1989).

High electrolyte concentration is the only common feature of all salt-affected soils. Their chemistry, morphology, pH and many other properties may be different, depending on the character of salinization and/or alkalization.

In the broader sense, salt-affected soils can be divided into the following groups:

1 Saline soils that develop under the influence of electrolytes of sodium salts with nearly neutral reaction (dominantly Na_2SO_4, NaCl, seldom $NaNO_3$). These soils occur mainly in arid and semi-arid conditions and form a major part of all the salt-affected soils of the world.

2 The alkali soils that develop under the influence of electrolytes capable of alkaline hydrolysis (Mainly Na_2CO_3 and $NaHCO_3$ and seldom Na_2SiO_3 and $NaHSiO_3$). This group is extensive in practically all climatic regions, from the humid tropics to beyond the polar circles. Their total salt content is commonly lower than that of saline soils, sometimes even strongly alkaline.

3 The salt-affected soils that mostly develop owing to the presence of $CaSO_4$ (gypsiferous soils) or, rarely, in the presence of $CaCl_2$. Gypsiferous soils can mainly be found in the arid and semi-arid regions of North America, North Africa, the Near-, Middle- and Far-East and also in Australia.

4 Salt-affected soils which develop under the influence of magnesium salts. This group occurs and is particularly significant in arid, semi-arid and even semi-humid conditions, especially in soils with a heavy texture.

5 Acid sulphate soils whose salt content is composed mainly of $Al_2/SO_4/_3$ and $Fe_2/SO_4/_3$. These types of salt-affected soils are generally extensive in tidal marsh areas along the

Type of salt affected soils	Electrolyte(s) causing salinity and/or alkalinity	Environment	Properties causing plant and crop stress	Indicator species of of halophytes and halofrequent xerophytes	Possibilities of utilizing the natural plant covering	Methods for reclamation
Saline soils	Sodium chloride and sulphate (in extreme cases, nitrate)	Arid and semi-arid	High osmotic pressure of soil solution, toxic effect of chlorides	*Salicornia berbera, Salsola soda, S. crassa, Suaeda microphylla*, etc	Herb and fodder of poor value	Removal of excess salt (leaching)
				Tamarix and *Carex*	Fuel	
Alkali soils	Sodium ions capable of alkaline hydrolysis	Semi-arid, semi-humid and humid	High (alkali) pH, poor water physical conditions	*Artemisias, Statice gmelini*, various *Festucas* and *Melilotuses*	Herb and fodder of poor value	Lowering or neutralizing the high pH by chemical amendments
Magnesium soils	Magnesium ions	Semi-arid and semi-humid	Toxic effect, high osmotic pressure, Ca deficiency	*Spergularia salina, Suaeda maritima*, etc	Herb and fodder of poor value	Chemical amendments, leaching
Gypsiferous soils	Calcium ions (mainly $CaSO_4$)	Semi-arid and arid	Low (acidic) pH, toxic effect	*Ligneum spartum, Limonium delicatulum*	Herb and fodder of poor value	Alkaline amendments
Acid sulphate soils	Ferric and aluminium ions (mainly sulphates)	Seashores and lagoons with heavy, sulphate-containing sediments, diluvial inland slopes and depressions	High acidity and the toxic effect of aluminium	Various reeds, mangroves, white cedar, etc	Fuel	Liming

Table 1: Grouping of salt-affected soils and their properties in relation to halophytes

seashores of all the continents. They are particularly common in North Europe, the western and eastern coastlines of Africa, along the coastline of southeast India, etc, and develop on sulphurous marine sediments.

Inland acid sulphate soils can also be found in different areas of the world, such as the western territories of the USA, Asia Minor and China. Such soils developed as a result of fluvial glacial processes and have had no connection with seashores in recent geological times.

Evidently the different groups of salt-affected soils have diverse physico-chemical and biological properties besides the one they have in common - ie, a comparatively high electrolyte content.

Besides the salt-affected soils that develop due to natural soil-forming processes, there are also so-called *secondary* salt-affected soils which are becoming increasingly important, both in scientific and practical terms. Secondary salt-affected soils are those which have been salinized due to man-made factors, mainly as a consequence of improper methods of irrigation. The extent of secondary salt-affected soils is rather sizeable and this adverse process is as old as irrigated agriculture itself. Old civilizations in Mesopotamia, China and Pre-Columbian America fell, partly, as a consequence of the salinization of irrigated land. At present, the process is continuing vigorously and more than half of all global irrigated lands are under the influence of secondary salinization and/or alkalization (figure 3).

When speaking of the man-made factors of salinization we must also mention soils which are not salt-affected at present but, in the event of the extension of irrigation, deforestation, overgrazing and other human activities, can and will be salinized unless the necessary preventive measures are taken in due time. No global records are available of the size of potential salt-affected soils but their area is larger than that of the existing salt-affected soils.

Halophytes - where they grow and what they can be used for

Each group of salt-affected soils behaves differently in relation to halophytes and sometimes xerophytes. Table 1 indicates the properties, environmental conditions and relation to halophytes of each group of salt-affected soils. It is clear that the different types of salt-affected soils have different chemical and physical properties which, in turn, have different effects on the conditions of plant life. It can also be generally accepted that certain limiting factors exist in all types of salt-affected soils. They make life impossible for many plant species and, as a rule, only permit the development of such associations which are more or less able to tolerate the salinity and/or alkalinity of the soil.

Such interrelations can be characterized for the different groups of salt-affected soils as follows:

Saline Soils

In saline soils, which account for the overwhelming majority of all salt-affected soils on Earth, high salt concentration and consequently high osmotic pressure constitute the limiting factors for the biota. As a rule, most of the salts are sodium salts of neutral pH (sodium chloride, sodium sulphate and sometimes sodium nitrate). Very often, when speaking of salt-affected soils, this groups is considered as a subject of salinity in the top layer of the land.

The natural vegetation growing sometimes sparsely on saline soils consists of halophytes. The distribution of species depends on both aridity conditions and on the chemical composition of salt. The physical properties of the soil - most of all, particle size distribution - also influence the composition of halophyte species. The indicator species for salinity are numerous and mostly perennial. However there are a few annuals which always reveal some particular characteristics of the saline soil (humidity, chemical composition of salts, etc).

A broad variation of different halophyte associations growing on saline soils are described in the different handbooks (International Source Book, 1967).

In the following, only those representatives of halophyte and xerophyte vegetations which have very direct correlations with soil condition will be mentioned - ie, the species most common in the different varieties of saline soils *(Salicornia herbera, Puccinellia gigantea, Salsola crassa, Suaeda microphylla*, etc).

Evidently some of them, (eg, *Salsola soda*) grow not only on saline but also on alkali soils because they also tolerate high alkalinity. Also characteristic of both saline and alkali soils are *Statice gmelini*, *Achillea cristata*, *Aster tripolium* and others.

Of the ligneous plants, the different types of tamarisks (*Tamarix ramosissima, T. gallica, T. balansae*) deserve attention, as does *Haloxylon ammodendron* on sandy soils which grows together with *Calligonium* bushes. They are used as fuel, medicinal herbs and for technical purposes by the local population.

On saline soils with high humidity, different halophyte Carex species can be found. In salt-affected marshy or flooded areas, *Bolboschoenus maritimus* and *Scirpus maritimus* often occur together with *Carex divisa* and *Juncus maritumus*.

Only a few of halophyte herbs can be used as a fodder which is, in any case, of poor value and only used in exceptional cases.

Alkali Soils

Alkali soils can be subdivided into two subgroups: (a) alkali soils with a high concentration of sodium carbonate and having no

Figure 2: Salinization and alkalinization caused by stagnant water. Photo: Szabolcs.

Figure 3: Salt accumulation along irrigation canal. Photo: Szabolcs.

typical columnar structure in the profile, and (b) alkali soils with comparatively low salt concentration and having a structural B horizon in the profile (solonetz type).

Consequently the halophytes and xerophytes growing on alkali soils differ in accordance with the different properties of these two subtypes.

In solonetz soils in particular, it is not the high salt concentration but the poor water physical properties which are responsible for hindering plant life. Consequently the vegetation on these soils only partly consists of halophytes with halo-frequent xerophytes accounting for a significant proportion.

In subgroup (a), *Salsola soda*, *Festuca ovina* and *Camphorosma ovata* often occur together with *Statice gmelini* and *Puccinellia limosa*. The latter also can be found in subgroup (b) in cases of high alkalinity.

Together with some halophytic species, in solonetz soils xerophytes or halofrequent xerophytes prevail. First of all, different kinds of sage (*Artemisia maritima*, *A. monogyna*, *A. alba*, etc), *Statice gmelini*, *Festuca ovina* and *F. pseudovina*. In cases of low salt concentration, *Achillea millefolium*, *Hordeum gussonearum*, *Aster tripolium* and *Poa bulbosa*, even *Proa pretensis* are found.

Parallel with the lowering of salt concentration, the leguminae (*Melilotus indica*, *Medicago hispida*, *Trifolium maritinum*, etc) and herbs typical to the no-salt affected surrounding areas, also appear.

Among the halophytes, *Puccinellia limosa*, in particular, has a high value as fodder, despite its low yield due to the poor ecological conditions. Nevertheless, with irrigation and the application of nitrogen fertilizers, in several countries, such as Hungary, it helps considerably in solving fodder problems in dry areas.

There have been similar experiences with a number of local xerophytes and halophytes in different countries where efforts have been made to relieve the fodder problem that always arises in salt-affected areas. Evidently in cases of low alkalinity and salinity, there are more possibilities for producing fodder crops.

Magnesium Soils

In magnesium soils, representatives of the two former groups can often be found, depending on the salt concentration and on the alkalinity of the soil. Apart from this, some specific plant associations are characteristic of magnesium soils, eg. *Spergularia salina* and *Suaeda maritima* in soils containing magnesium carbonate, or *Ormenis praecox* and *Beta macrocarpa* in saline magnesium soils.

Gypsiferous Soils

Gypsiferous soils are extensive in semi-arid and arid areas and, in most cases, the gypsophilic xerophytes prevail among their natural plant associations. *Lygneum spartum* and *Limonium delicatulum* are specific of the calcic gypseous salt-affected soils in the Middle East. *Arthrocnemum glaucum* cushions occur on micro relief. *Inula crithmoides* also occurs frequently on gypsiferous soils.

Acid Sulphate Soils

On acid sulphate soils a diverse vegetation can be found, depending on local geographical conditions. The development of the various herbaceous species is also subject to the degree of salinity and acidity of the soil and they can scarcely be used as fodder.

It is well-known that acid sulphate soils are well-developed in mangrove ecosystems whose biota is determined by such circumstances. Reed vegetation in brackish swamps is also associated with acid sulphate soils, for example, in West Africa where *Racemose* is common, or in South America where *Rhizophora mangle* has been studied (Brinkmann and Pons, 1973). In freshwater areas, *Imperate brasiliensis* (white cedar) is characteristic of South America. In eastern Asia, *Melaleuca* can be observed. The latter has a wide ecological amplitude.

The halophytic and xerophytic vegetation, typical of the different groups of salt-affected soils has considerable significance in national parks and other environmentally-protected areas. Together with native ecological factors, the preservation of native xerophytic and halophytic vegetation on salt-affected soils is a substantial part of keeping protected lands undisturbed.

Conclusion

The close interrelations between ecosystems and soils make it possible to differentiate between the soil types associated with a certain type of vegetation. In this respect, salt-affected soils are closely related to halophytes.

The different groups of salt-affected soils can be associated with different groups of halophytes and xerophytes. Several soil attributes are preconditions to the development of certain plant associations.

There is a high diversity of halophytes, xerophytes and other plant associations in the different areas of the world covered by different types of salt-affected soils.

In order to promote the better knowledge and better utilization of the halophytic vegetation in salt-affected areas, further studies are necessary so that the complex interrelations between the soil conditions of salt-affected areas and the vegetation growing on them can be revealed.

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Spatial Scales and Desertification

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Abstract

This essay explores the different spatial scales of the process of desertification. It is suggested that one reason why peasant farmers do not adapt to the early stages of desertification is because of the gap between the local geographical scales at which decisions leading to desertification are taken by farmers and herders, and the regional or subcontinental geographical scales at which the environmental response is perceived. The unit of account by which sedentary farmers make decisions is compared to the geographical scales at which indicators of desertification can be detected.

Introduction

In the literature on desertification, the issue of time scale has been widely discussed: the causes attributed to desertification vary according to whether it is viewed as a phenomena occurring within a geological time scale (El-Baz, 1983) or as a man-induced process occurring over a shorter time span (Dregne, 1984). The need to collect long time series data on land surface parameters in order to distinguish between the aperiodic variability in time of rainfall and biomass productivity, and the longer-term trends affecting the biophysical characteristics of semi-arid ecosystems have also been recognized (Hellden, 1991; Rhodes, 1991). Surprisingly, the issue of spatial scale has usually been ignored. It is argued in this essay that a better understanding of the multiple spatial scales involved in desertification might contribute to clarify some aspects of the causes of this process, as well as to improve the implementation of desertification control strategies.

There are considerable differences in the scales at which scientists from different disciplines study desertification. Desertification is best detected (and probably only conceived) on a continental or sub-continental scale - the macro-management level - yet it is the product of innumerable land-use decisions at the local or micro-management level. The concept of desertification implicitly refers to land cover changes affecting large areas, but the progressive degradation of the vegetative cover, the erosion of soil, the salinization and crusting of soil, and the reduction of soil organic matter - which are the main processes of desertification (Sanders, 1986) - all have local causes. Part of the controversy surrounding the concept of desertification might well be related to this discrepancy between the spatial scales at which the effects are perceived (and conceived) and the causes are acting. This has direct implications for the design and implementation of desertification control measures: the way rural communities perceive the problem in spatial terms might differ completely from that of the project designer. This essay explores the different spatial scales involved in the process of desertification and examines the implications of this issue.

Spatial Scales

In order to contribute to the understanding and prediction of environmental changes, one of the complex problems that the human ecologist has to face today is the question of spatial scales. The concept of scale is understood here according to its observation spatial meaning, i.e. the spatial extent of study, rather than according to its cartographic meaning (Lam and Quattrochi, 1992). The spatial scale is related to the concepts of resolution (the smallest distinguishable parts in an object or a sequence) and level of organization of the landscape (the place within a hierarchy). Broad spatial scale refers to a large study area, coarse resolution and high level of organization. Fine scale refers to a small study area, high resolution and low level of organization (Turner *et al*, 1989).

Human-induced changes to the environment occur today at a wide variety of geographical scales: from the field to the global ecosystem. From the second half of the nineteenth century, the spatial scale of environmental concerns has continuously increased by several orders of magnitude

(Clark and Holling, 1985). When studying landscape processes, it is important to understand and anticipate the implications of moving from one scale to another. The processes occurring at different scales, though interrelated, are different in magnitude, trends and forces involved. For example, it has been shown that results of measurements of erosion processes performed at one spatial scale can differ from those at another scale by several orders of magnitude (Millington *et al*, 1982). This is related to the observation that the relative importance of parameters controlling ecological processes vary with the level of integration of the system. Although moving to a coarser scale may result in loss of discernible or treatable detail, it also may result in the appearance of emergent properties due to synergisms at a higher level of system integration. These interactions are sometimes not seen at finer scales but, also, they are perhaps not active at these scales if finer scale means a lower level of integration. Decreased size (finer scale) loses some interactions and thus some functional properties (Meentemeyer and Box, 1987). In other words, the scale at which studies are conducted may profoundly influence the conclusions since processes and parameters that are important at one scale may not be as important or predictive at another scale (Turner *et al.*).

Causes of Desertification

A large part of the ambiguity over the causes of desertification is that different causal processes operate together in a particular place over differing time and spatial scales: long-term climatic changes at a global scale, short-term climatic variability at a regional scale and short-term human action at a local scale. According to Blaikie (1985), 'it is often difficult to single out the effects of humans on soil erosion and sedimentation rates, from other effects such as climatic change, and ongoing 'natural' erosion processes.' Only short-term data are currently available on the climate and ecology of most regions affected by desertification. This not only prevents longitudinal studies of ecological change but also prevents comprehension of the real spatial dimension of desertification, since it is known that the time period of observation should be matched with the size of the area involved (Meentemeyer and Box, 1987). Large areas involve long observation periods because large-area systems have long relaxation times. Smaller areas can be analyzed in a shorter time frame.

The anthropogenic causes of desertification in semi-arid, developing regions are well known: firewood cutting in rural areas and around main cities, overtaxed rangeland carrying capacity and overgrazing by ever-expanding herds, cultivation in ecologically marginal areas and agricultural over-exploitation, low level of agricultural technology, reduced fallow time, deep well construction, practice of annual bush fires during the dry season, land tenure systems and cultural rivalries between ethnic groups (United Nations, 1977; Kovda, 1980; Glantz, 1980; Sanders, 1986). Some authors have tried to make the concept of desertification easier to understand by organizing existing information about this process into different levels of analysis. Glantz (1980) has distinguished three levels of awareness and interaction which influence desertification in West Africa: human nature and behaviour, the State and the international system. His analysis suggests that the underlying causes of desertification often relate to human nature and behaviour; that is, at the first level of social organization. This level has often been neglected by research, while the two other levels - the State and the international system - have received the most attention. I will thus focus my analysis on the individual level of decision-making where the behavior of individuals is influenced by their own perception of the environment.

Scale Displacement Effect - the Gap Between Spatial Scales

It is well known that in resource exploitation there is a conflict between individual and community levels, as well as between short-term needs and longer-term requirements. To this gap between two decision-making levels and two temporal scales can be added the gap between geographical scales. The contribution of human activity to desertification dynamics is much better understood when the different spatial scales involved in this process are identified and when the level of decision-making is compared to the many different levels of organization of the environment.

Why do farmers and herders, who have shown over the centuries the ability to develop sophisticated strategies to adapt their farming systems to fluctuating climatic conditions, enter the vicious circle of over-exploitation and environmental destruction? Why are they now, in some cases, unable to adapt their farming system to the new challenge brought by the modern era - ie, an ever-expanding population in a fragile environment? It can be more easily explained if the gap that exists between the local geographical scale at which decisions leading to desertification are taken by farmers and herders, and the regional or subcontinental geographical scales at which the response of the environment is perceived and detected is acknowledged.

Unit of Account of Decision-Making

The central idea behind this explanation is the emphasis that is given in desertification analysis to the problem of decision-making within boundaries. The geographical scale of the 'unit of account' (eg, field, farm, watershed) is usually tied closely with the decision-making process over land use, conservation and degradation (Blaikie and Brookfield, 1987). The decisions to cut a tree, cultivate a piece of land or graze cattle on given spots are all local decisions. They are based on the perception of the immediate surroundings, ie, on the mental map a farmer has of his everyday space. In traditional sedentary agrarian systems this everyday space is geographically restricted to an area which does not extend very far beyond cropping, hunting and firewood gathering areas. The direct and accurate perception of ecological degradation at the level of this limited space occurs only after the desertification process has reached a very advanced stage and is usually irreversible within a human life-time. Before becoming this extreme, desertification has gone through a number of stages where it was not immediately perceptible at the local scale. This problem - ie, that land managers do not perceive this degradation pattern - has already been noted by Blaikie and Brookfield (1987):

Ignorance of subtle changes in the quality of the soil is not only possible, but widespread. There is a number of degrading processes which show little immediate effect until a threshold of resilience is past, or until some untoward event exposes an increase in sensitivity. (...) It is possible for land managers to remain quite ignorant of the effects of low rates of erosion, where these exceed still lower rates of soil formation, until a critical level of accumulated loss is reached, and this can even take centuries. (...) A succession of good years can delay the perception of degradation to a critical extent, or at least facilitate an optimistic ignorance of the real consequences of observable changes.

Ignorance of degradation and its perception depends on the rate and accumulated degree of degradation, but also on the geographical scale at which the degradation occurs.

Spatial Scale for Desertification Assessment

There is seldom a neat one-to-one correspondence between the geographical scale of environmental impact and the level of decision-making. Decisions taken at the farm level can have repercussions at the regional level. An analysis of the environmental consequences of decision-making often requires a broadening of geographical scale. This is the case with desertification since the minimum size of area affected is implicitly one to several orders of magnitude greater than the size of a field or of the immediate surroundings of a deep well.

Desertification assessment in an environment characterized by a mosaic of land cover and land use patterns requires an indirect approach with a scale-generalization of the effects of several contributory phenomena across a wide geographical area. To assess the status and trends of desertification, indicators have been identified among physical, biological and human phenomena (Mabutt, 1986). It is interesting to note that the most useful indicators are defined at subcontinental or regional geographical scales: albedo, frequency of dust storms, soil erosion at regional scale, standing biomass on a wide area, etc. The only indicators of desertification which are defined at the local scale, and thus which can be perceived immediately by farmers, are related to human biological parameters (nutritional status, public health) or social process parameters (conflict, migration, cash versus subsistence crops). However, the applicability of these local human indicators is questionable since there is a heightened risk of incorporating the expression of conditions not intrinsically part of the process being monitored. For example, worsening nutritional status within a population group could indicate changing economic status, independent of local environmental conditions (Mabutt, 1986). Many desertification indicators are scannable by satellite imagery (eg, Olsson, 1985). Other indicators call for repeated ground measurements by skilled technicians. Such site measurements are based on a network of widely distributed observation stations, located according to a sampling frame which is designed to grasp the high spatial variability of ecological conditions in semi-arid regions. Complex spatio-temporal interpolation methods have to be applied in order to get a synoptic figure of the state of the environment.

This discussion clearly establishes that the early identification of the process of desertification is performed at very coarse geographical scales, through indirect and sophisticated observation techniques. The early stages of desertification are not detected at the local scale, which corresponds to the scale of everyday perception by the individuals responsible for desertification processes. The local farmer or pastoralist clearly does not have access to the observational means that allow for perception of the landscape at the broad spatial scales at which the preliminary stages of desertification can be observed. Thus desertification, as opposed to drought, for instance, cannot be detected in a comprehensive way in its early stages by land managers involved in traditional farming systems.

Human Behaviour and Environmental Perception

This gap between the spatial scales at which individuals or small groups make the relevant decisions, and the scales involving generalized patterns of land degradation is such that, in some cases, common sense and visual evidence are poor guides by which to perceive indicators of land degradation. The behavioural sciences have demonstrated that human actions are mediated by cognition of the environment - cognition being defined as the mental processes by which people acquire, organize and use knowledge (Gold, 1980). Perceptions about the environment are the basis for human activities and although these perceptions may be inaccurate reflections of 'reality', the consequences of those activities will be real. Important causes of desertification may result from this (Glantz, 1980). The individual actions at the local scale which lead to desertification are based on the 'behavioural environment' which is characterized by a lack of perception of the broadest scale consequences of these actions. As a consequence, the environmental cost of these actions is not taken into account in the decision-making process. Therefore, not only it is very difficult to justify many land conservation practices for the individual farmer on economic grounds, but it means that any analysis of the rational behind decision-making that leads to environmental degradation should be based on the perceived (or behavioural) environment rather than simply on the physical reality.

Conclusion

The analysis of geographical scales is an important component of the understanding of a process of environmental degradation such as desertification. It is important to understand clearly at what geographical level land-management decisions are made to identify the spatial units of account for assessing costs and benefits of these decisions. It is as important to take into account the behavioural environment, at which level the cost of land management decisions is sometimes not perceived. I have shown that this situation occurs when the degradation process can only be perceived on a regional scale. In other words, I have stressed the need for an appreciation of the different spatial scales of the causes and consequences of desertification processes.

If local populations do not recognize the significance of the problem they cannot be expected to seek actively a solution to it. The practical implication of this idea is that efforts towards educating local opinion to establish incentives for community participation in programmes to combat desertification will miscarry unless the measures relate to the problem as it is perceived by local residents (Mabutt, 1977). Therefore, desertification control strategies must be designed on the basis of local studies of how specific rural communities perceive the environment. If the spatial scale issue is integrated into desertification control strategies, it should contribute to a better definition of measures to influence land use practices in regions prone to human induced land degradation.

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Map of Human Induced Land Degradation in the Aral Sea Basin

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Summary

The Aral Sea Basin occupies 2.0 million km², 80 per cent of which lies within the borders of Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan. A new methodology was proposed to study human-induced land degradation and a map at the scale of 1:2,500,000 was prepared. Space images at a scale of 1:1,000,000 were used. The map contains information about land use, types of land degradation and the size of areas subject to degradation.

Introduction

The Aral Sea Basin occupies 2.0 million km² of which about 80 per cent or about 1.6 million km² are within the borders of the former Soviet Union. This territory belongs to Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan. The remaining 20 per cent lies within the territory of Iran and Afghanistan.

The physical conditions of the regions closely correlate with two main orographic areas - the Turan Plain in the north and the high mountains of Kopetdag, Hindu Kush and Tian Shan in the south. In the low lands, atmospheric precipitations total 90-120 mm, in the piedmont plains 400-500 mm and on the western slopes of Tian Shan more than 2,000 mm per annum.

The ecological situation of the Aral Sea Basin represents a unique example of environmental degradation caused by the destructive activity of man. The area bordering the Aral Sea has been transformed into an ecological disaster zone. The waters of two big rivers - the Amudarya and the Sirdarya - were taken off for irrigation purposes. In 1960, the surface waters of the Aral Sea measured 64,113 km². By 1991, they had been reduced to 34,113 km² (I.E. Timashev, 1991).

Irrigated farmlands in oases have decreased in productivity because of salinization. Ground waters are subject to contamination by pesticides and herbicides. Living conditions of people in these areas has become intolerable (N.F. Glasovsky, 1990).

The object of this study was to assess human-induced land degradation in the Aral Sea Basin and to create a database relating to this.

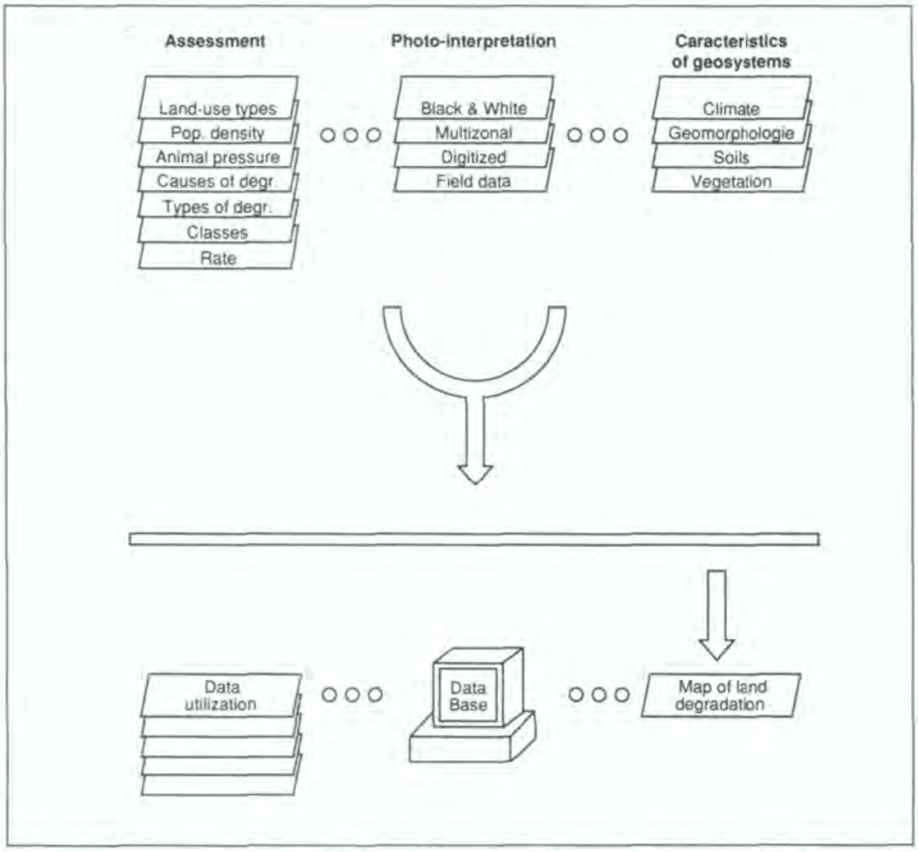

Figure 1: Conceptual strategy behind compilation of the human-induced land degradation map.

Criteria	Classes Slight	 Moderate	 Severe
Degradation of Vegetative Cover			
1. Status of plant communities	Climax or slightly changed	Long existing	Ephemeral
2. Loss of productivity	<15%	15-40%	>40%
3. Reduction of plant cover	<10%	10-40%	>40%
Wind Erosion			
1. Amount of moving sand dunes	<30%	30-70%	>70%
2. Sod cover	30-50%	10-30%	<10%
Water Erosion			
Type of erosion	Surface wash,	Surface wash,	Gully erosion,
1. single washouts	<10 washouts per 1 km of transverse section	>10 washouts per 1 km of transverse section	
2. Washout of the upper soil horizon	<5 cm	5-20 cm	>20 cm
3. Reduction of plant cover:			
Tree and shrub layer	<20%	20-50%	>50%
Herbaceous layer	<20%	20-50%	>50%
Salinization of Irrigated Farm Lands			
1. Salinization degree, dense residue (total solids)	0.21-0.40%	0.40-0.60%	>0.60%
2. Mineralization of ground water	3-6g per litre	6-10g per litre	>10g per litre
3. Mineralization of irrigation water	0.5-1.0g per litre	1.0-1.5g per litre	>1.5g per litre
4. Decrease in agricultural crop production (cotton)	<15%	15-40%	40-80%
5. Seasonal accumulation of salts	16-30 MT per ha	30-45 MT per ha	>45 MT per ha
6. Contamination of irrigation water (ration of toxic substances to their permissible content)	1.6-6.0g per litre	6.0-11.0g per litre	>11.0g per litre
Salt Salinization in Areas Bordering the Aral Sea			
1. Change in soils caused by the fall in sea level	Initial stage of desert soil formation, accumulation of sand on the soil surface	Formation of maritime solonchak suitable for plant growth	Formation of deep solonchak non-suitable for plant growth
2. Salt content in the first 100 cm of soil layer	<130 MT per ha	130-290 MT per ha	290-370 MT per ha

Criteria	Classes Slight	Moderate	Severe
3. Change in plant cover	Appearance of *Haloxylon aphyllum* plants and some semi-shrubs	Appearance of Tamarix species of plants	Bare land
Waterlogging of Desert Rangelands			
1. Plant cover of hygrophytes and phreatophytes: Tamarix species, *Alhagi australis*	<30%	-	-
Tamarix species, *Alhagi australis, Carelinia caspica*	-	30-70%	-
Fragmites australis, Glycyrrhiza glabra, Alhagi australis	-	-	>70%
2. Depth of fresh or weakly mineralized ground waters	5 m	2-5 m	<2 m
3. Regime of soil moisture	Automorphic	Semi-hydromorphic	Hydromorphic
Technogenic Desertification			
1. Disturbances of plant cover:			
Cutting of trees and shrubs	<25%	25-50%	>50%
Sod cover destruction	<25%	25-50%	>50%
2. Eroded area caused by irregular movement of vehicles	<10%	10-25%	>25%
3. Area covered with technogenic sands	<10%	10-25%	>25%
4. Length of all types of roads (in linear km per 100 km²)	<40	40-80	>80

Table 1: Criteria for the Assessment of Land Degradation

Material and Method

Various sources of information were used to prepare the map - the conceptual strategy behind its preparation is explained in figure 1. A set of layers was used to study physical conditions, to obtain information from space photos and to assess land degradation.

Thematic maps of various scales (1:1,000,000-1:2,500,000) were used. All maps were reduced to one scale (1:2,500,000) which made it possible to overlap them (lay them on top of each other) for studying.

We also used Soviet space photos of 1:1,000,000 scale, obtained during 1989-1991, and small-scale *Meteor* satellite photos of low ground resolution. Most of the area was interpreted ocularly and only a small part of the territory - mostly oases with complex features - was studied by digitized imagery.

From these studies we developed the criteria for the assessment of land degradation. First, we identified the following types of land degradation: degradation of the vegetative cover, wind erosion, water erosion, salinization of irrigated farmlands, soil salinization in the areas bordering the Aral Sea, waterlogging of desert rangelands and technogenic desertification. The assessment scale includes the following three classes of land degradation:

Degree of degradation of geosystem	Class of degradation
Non-degraded or slightly degraded	Slight
Moderately degraded	Moderate
Severely degraded (including full loss of biological productivity	Severe

We developed our criteria for assessing land degradation, taking into consideration the previous study by N.G. Kharin, N.T. Nechaeva *et al*, (1985). Their criteria are shown in table 1.

It should be mentioned here that normal land degradation progresses from slight to severe desertification. But land degradation in areas bordering the Aral Sea is a reverse process. As it dries up, the biological potential of the sea bed is resorted and within 20-25 years is covered with vegetation. Degradation of this vegetative cover is caused by overgrazing and unwarranted cutting of trees and shrubs for fuel. Wind erosion mainly occurs in the sandy deserts where ecosystems are not stable. We have taken into account only the erosion that is caused by man's interference. Moving sand dunes of natural origin were not considered to be land degradation.

Technogenic desertification is observed everywhere that man has actively interfered with nature. It is caused by the movements of machines and mechanisms in the desert (around derricks, along irrigation canals, in construction sites, etc). This type of land degradation is very specific and needs special measures for rehabilitation of the vegetative cover.

Waterlogging of desert rangelands also needs some explanation. This process is common in the places where used drainage waters are piped without control from oases to desert lands. It leads not only to deterioration of grazing lands but also hinders the free movement of livestock herds.

A computerized database was compiled on land degradation using the following parameters: number of geosystem, size in km^2, name of state, precipitation rate, geomorphology, soil texture, plant association, land use type, population pressure, animal pressure, type of land degradation, class of land degradation and rate of degradation.

Results and Discussion

As a result of this case study, a map of land degradation at a scale of 1:2,500,000 was compiled. According to N.G. Kharin, N.T. Nechaiva *et al* (1986), desertification maps (or similar maps of land degradation) are compiled at three levels: large-scale maps of 1:100,000 and larger; medium-scale maps of 1:250,000-1:500,000; and small-scale maps of 1:1,000,000-1:1,2,500,000). Large-scale maps are used to develop projects on land improvement of small administrative units. Medium-scale maps are used for the development of land utilization and nature conservation measures at a regional level, within the limits of administrative provinces (*oblast* in Russian).

What is the role of small-scale maps? First, a small-scale map of land degradation gives a synoptic view of vast areas. The results obtained give information on the size of degraded lands (table 2).

It can be seen that degradation of the vegetative cover dominates over other types of land degradation. It should be empha-

Classes / Types	Slight km^2	Slight %	Moderate km^2	Moderate %	Severe km^2	Severe %	Total km^2	Total %
Degradation of the vegetative cover	750,954	52.3	307,957	21.4	23,704	1.6	1,082,615	75.3
Wind erosion	14,677	1.0	2,140	0.2	3,970	0.3	20,667	1.5
Water erosion	53,009	3.8	29,569	2.1	-	-	82,578	5.9
Salinization of irrigated farmlands	12,959	0.9	105,095	7.4	39,055	2.7	157,099	11.0
Soil salinization on borders of Aral Sea	6,115	0.4	4,027	0.3	39,055	2.7	49,197	3.4
Technogenic desertification	-	-	20,208	1.4	14,296	1.0	34,504	2.4
Waterlogging of desert rangelands	-	-	5,360	0.4	1,620	0.1	6,980	0.5
Total	**837,714**	**58.4**	**474,356**	**33.1**	**121,700**	**8.5**	**1,433,770**	**100**

Non-utilized land	**Total**
Moving sand dunes	14,175
Solonchak	41,146
State border zone	9,100
Lakes and storage lakes	49,120
Rock outcrops	60,479
Glaciers	9,600
Total	**183,620**
Total of the Aral Sea Basin	**1,617,390**

Table 2: Size of the Areas of Land Degradation in the Aral Sea Basin of lands used in the national economy

sized here that all irrigated farmlands are subject to salinization.

The severe ecological situation shown by the map calls for the development of a general strategy to overcome the disaster. To our great regret, the former Soviet Republics (now independent states) do not have a common strategy. National ambitions and misinterpretations of sovereignty are obstacles to finding a solution to the problem.

Land degradation is especially important for Kazakhstan, Uzbekistan and Turkmenistan which have big oases of irrigated farmlands in the area bordering the Aral Sea.

As was previously mentioned, part of the Aral Sea Basin is situated in Afghanistan and Iran. Afghanistan in future may utilize the Amudarya River which will aggravate the ecological situation still further.

Under such conditions the restoration of the Aral Sea in the near future will be impossible. The further reduction of the Sea water surface will lead to severe salinization of soils in oases and to the deterioration of living conditions of the people.

This is the first map of land degradation which covers the whole territory of the Aral Sea Basin. The map and database can be used as a basis for developing a monitoring system. This is necessary for the study of the dynamics of land degradation and for the development of a strategy to combat desertification.

Acknowledgements

This study was enhanced by the cooperation of the following scientists from the Desert Institute: A.M. Babaiv, K. Kurbanmuradov, P. Esenov, A.A. Kiriltseva and B.M. Ivakhov. Our special thanks are extended to Prof. A.G.Babaev, Scientific Advisor to the project and Director of the Desert Institute.

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Ground Radiometry for Measuring Healthy and Stressed Vegetation in a Simulated Arid Environment

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Abstract

Hand-held radiometers were used to measure spectral radiance from healthy and stressed vegetation in an attempt to assess and separate them spectrally. In the first of our two experiments, three levels of irrigation and four levels of defoliation and fertilizer treatments were applied. We found that it was possible to estimate spectral and separate nutrient and water deficient crops from the control.

In the second experiment, grass was allowed to develop and senesce (turn brown with age). The variation in spectral value was recorded after its regeneration which led to an under-estimation of its biomass. The relationship between the red, green leaf area index (GLAI), brown leaf area index (BLAI) and yield were insignificant. Only the near infrared reflectance (NIR) and perpendicular vegetation index (PVI) provided a better means of monitoring and separation of green grass from brown (senesced) vegetation.

The results indicate that hand-held radiometers may be useful in monitoring grass vegetation in semi-arid environments.

Introduction

Spectral data obtained from hand-held radiometers with band passes similar to data from airborne and spaceborne sensors provide an important method for testing the potential of remote sensing techniques for estimating the biomass of crops or plants under known stresses. Knipling (1967) and Gates (1969) showed that leaves on plants experiencing environmental stresses could be spectrally discriminated from healthy green leaves.

Nutrient and water deficits could also be detected as they influence the reflectance of the leaves. For example, Thomas *et al* (1966) found that the effect of limited nitrogen increased the visible radiation in cotton leaves. Vegetation or canopy variables such as biomass, leaf area and percent cover have also been related to spectral radiometric data (Holben *et al*, 1980; and Asse and Siddoway, 1981).

However, both low phytomass and variable background effects present problems in both vegetation discrimination and biomass estimation in remote sensing. For instance, Kimes (1983) faced such problems while estimating vegetation type and amount from spectral data. Several indices based on red and NIR have been developed. These include the perpendicular vegetation index (PVI), (Richardson and Weigard, 1977); the vegetation ration (VR), (Curran and Milton, 1986); the normalized vegetation index (NDVI), (Tucker, 1979); the green leaf area index (GLAI), (Curran, 1987) and the soil brightness index (SBI), (Taylor *et al*, 1986). These multispectral measures have been widely used to develop regression equations between canopy reflectance values and total fresh and dry weights, and as measures of plant stress (Tucker, 1980; Curran, 1983a).

The two greenhouse experiments reported here compare the effectiveness of these measures in measuring growth and the onset of water- or nutrient-induced stress in a model grass canopy. The aim of the experiments was to assess the effects of water, defoliation and fertilizer treatments and their interactions on the spectral reflectances of the canopies and biomass of *Lolium perenne L.* (experiment I). In the first experiment, plants were subjected to two levels of irrigation, four levels of fertilizers and four levels of defoliation treatments. In the second experiment, the spectral response of actively growing grass (*Lolium perenne L.*) growth in large pots with low phytomass cover emerging from a soil background covered with dead brown vegetation was examined. This was in an attempt to investigate the possibility of discriminating the green from the brown vegetation using reflectance factors and vegetation indices.

Materials and Methods

Perennial Ryegrass (*Lolium perenne* cv. S23 L.) was grown from seeds in 25 cm pots at a density of 5,560 plants per pot in John Innes No. 1 compost. After germination, the grass was allowed to grow before applying the appropriate treatments. Pots were

Treatment	Red	NIR	VR	NDVI	Fresh weight (t/ha)	Dry weight (t/ha)
Daily water	27.47	347.47	13.17	0.85	256.05	31.2
Weekly water	23.77	321.82	13.86	0.86	156.56	25.11
No fertiliser	25.16	306.30	12.36	0.85	169.55	24.76
Nitrogen fertiliser	25.82	333.50	13.74	0.85	223.44	29.38
Phosphates/potassium fertiliser	25.00	343.00	14.34	0.86	195.16	29.93
Nitrogen/phosphates/ potassium fertiliser	26.48	355.70	13.62	0.85	238.08	31.54
No cut	23.35	408.50	17.81	0.86	400.13	59.35
Early cut	26.97	369.50	14.25	0.86	250.57	34.08
Late cut	25.00	300.50	12.36	0.85	107.14	11.73
Late/early cut	27.14	260.10	9.64	0.87	62.28	7.45

Table 1: The effects of water, fertilizer and defoliation treatments on the yield, red, NIR and vegetation at the first harvest

then arranged as latin squares within each block. Blocks were replicated twice, each consisting of 16 pots, and each pot received a treatment level. The irrigation treatment was left in blocks, but fertilizer and defoliation treatments were arranged as split plot design. There were four levels of defoliation treatment (no cut, early cut, late cut and early/late cut pots) and there were also four fertilizer treatment levels (no fertilizer, nitrogen only, phosphates and potassium fertilizers only and nitrogen, phosphates and potassium). Treatments began at slightly different times after randomization due to time differences and differences within treatments.

A Milton Multiband Radiometer (MMR) was used to measure spectral radiance in two visible bands (green and red) and two infrared bands (near-infrared and near-middle-infrared), (Milton, 1980). The radiometer was positioned at about 100 cm above the canopy and under two 500W lamps to reduce the effects of daylight fluctuations. All channels were read simultaneously. A Kodak grey card was then laid on the surface sample of pots and the grey card radiance measured as a standard reference. Immediately after each set of radiance measurements was completed, grass in appropriate treatments was cut at about 4 cm above the soil surface. After treatments, all pots were harvested twice. Prior to each harvest, all pots were spectrally measured. The clipped vegetation was weighed and oven dried at a temperature of about 70°C for about 72 hours.

In experiment II, seeds of the same grass were sown in July 1987 in 9 large pots of sand from the Aberffraw dune system (North Wales). A Long Ashton Nutrient Solution (LANS) was prepared at twice the recommended rate and applied twice a week. This was to allow accumulation of enough nutrient to allow crop growth and development. After spectral data were collected the vegetation was allowed to gradually wilt until it turned brown.

In December 1987, irrigation was resumed resulting in the growth of fresh tillers. The same quantities of LANS were reapplied at the same rate for two months. The proportion of green and brown leaves were estimated by a 'hit' count method of dropping a 30 cm metal pin 20 times in each pot at random. All leaf-pin contacts were counted and recorded accordingly. This provided the approximate density of live and dead leaves in each pot.

In the final sampling, all plants from a central, sample, 25 cm x 25 cm quadrat in each pot were harvested. A 100 cm central quadrat of the sample area from each pot was taken and green leaves separated from brown leaves.

In each case, leaf area was measured by an automatic leaf area meter (Model Hayashi Denkoh and Co., Japan). After fresh weights were taken, clipped leaves were oven-dried and reweighed.

A soil-line was constructed by taking red and NIR reflectance measurements from a series of air-dried sand samples wetted with a hand spray to give a range of soil moistures (dry, moist and wet). Dark-level-offset measurements obtained for each channel before and after each set of readings were subtracted from all observations. Red and NIR radiance were then expressed as a percentage of grey card values. The vegetation ratio (VR) and normalized difference vegetation index (NDVI) were then calculated as follows: VR = NIR reflectance divided by red reflectance (Steven, 1983). NDVI = the difference between NIR and red reflectance divided by the sum of the two (Tucker, 1979). Green and brown leaf area (GLAI/BLAI) indices were calculated for each plot. The GLAI was obtained by dividing the sum of green leaf area by the area of the sub-sampled quadrat. The sum of brown leaf area divided by the same quadrat area gave BLAI. Means of red and NIR reflectance were computed from each set of vegetation data to give vegetation points. These points were connected to the soil line at perpendicular angles to produce the perpendicular vegetation index (PVI), (Richardson and Wiegard, 1977).

Results

In experiment I, the red and NIR reflectance, and the VR and NDVI derived from the grass canopy radiance at various stages were related to fresh and dry biomass at the time of each cut. Only the data obtained from the two harvests are analyzed in detail and presented. The results obtained indicate that the spectral radiance measurements of the canopy were affected by the amount of live vegetation, moisture content and fertilizer applied (table 1).

At the early 'cut' stage both fertilizer and water treatments and their interactions failed to produce any significant effect on biomass and the relationship between yield and reflectance was not linear. Reflectance factors and indices at this stage failed to qualify as good predictors of yield.

Later, during the 'late cut' stage (72 days after planting), the effects of fertilizer treatments began to show, particularly that of nitrogen which became statistically significant. The NIR was significantly related to yield ($P < 0.01$) as well as the VR ($P < 0.05$).

At first harvest (85 days after planting), NIR values were strongly affected by both irrigation and defoliation treatments ($P<0.05$), both of which affected yield (figure 1). The red reflectance was only affected by water treatment levels ($P < 0.05$) and early cut treatment level ($P < 0.05$) but not biomass (figure 1).

By the second harvest (132 days after planting), most treatment levels had produced changes in the red and NIR reflectance and the VR (table 1). However, only the water treatment had an effect on the NDVI. Strong correlation was also registered between the NIR reflectance and the VR with yield (tables 2 and 3). An analysis of variance indicates that both water and nitrogen treatments produced highly significant differences in reflectance factors, vegetation indices and biomass ($P < 0.001$).

In the second experiment, there were no significant differences in spectral data recorded from all pots. Results obtained also show a significant correlation between NIR and GLAI with fresh weight ($P < 0.01$) and ($P < 0.05$) respectively, but not with dry biomass (table 4). A similar result was recorded between NDVI and GLAI. The proportion of live and dead leaves recorded as frequency of 'hits' by the pin is shown in figure 2 and indicates that brown leaves dominated the pots and were normally distributed. On the other hand, the green leaves represents a poisson distribution.

The PVI values of grass before and after senescence in relation to the soil are shown in figure 3 (page 32). The red reflectance values were not consistent with vegetation growth due to background effects. The NIR reflectance increased with vegetation amount during the first phase (a,b,c and d) but without a definite pattern in the second phase.

The relationship between the PVI and times of reading shows that the PVI increases with time as the vegetation develops. During the first phase, the PVI indicates a good separation between green vegetation and soil as the grass developed. Both GLAI and VR were not significantly related to dry biomass even though the GLAI was significantly correlated to fresh weight.

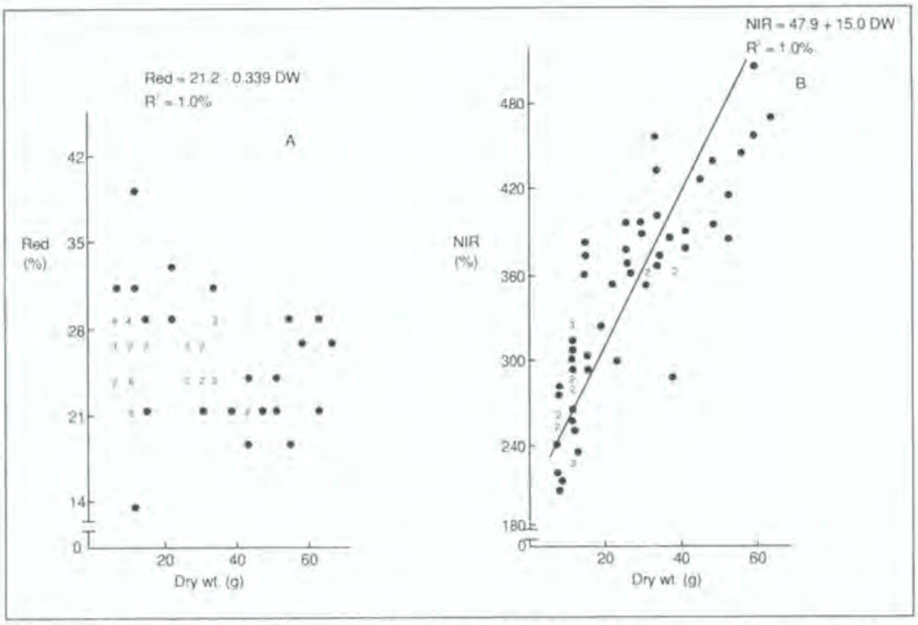

Figure 1: The relationships between (A) red and (B) NIR reflectance and dry weight at first harvest.

	Red	NIR	VR	NDVI	Fresh weight
NIR	-9.04				
VR	-0.65	0.77			
NDVI	-0.69	0.73	0.94		
Fresh weight	-0.02	0.87	0.70	0.57	
Dry weight	-0.10	0.86	0.76	0.62	0.96

Table 2: Correlation coefficient between treatments, red and NIR reflectance, vegetation indices and yield (first harvest)

	Red	NIR	VR	NDVI	Fresh weight
NIR	-0.58				
VR	-0.90	0.72			
NDVI	-0.34	0.40	0.51		
Fresh weight	-0.67	0.94	0.77	0.41	
Dry weight	-0.67	0.94	0.78	0.42	0.98

Table 3: Correlation coefficient between treatments, red and NIR reflectance, vegetation indices and yield (second harvest)

Discussion

In the first experiment, the spectral separation of the control and the nutrient deficient crop was more pronounced during the period of maximum growth. The NIR/Red ratopm (VR) value was significantly high at second harvest and discriminated between grass at maximum growth and treatments when the nutrients in the compost were beginning to be exhausted which led to pigment degradation. At this stage, the effect of nitrogen was highly significant; PK treatment was not. However, the effect

	Red	NIR	NDVI	VR	GLAI	BLAI	Dry weight
GLAI	-0.37	0.37	0.60	0.05			
BLAI	-0.06	-0.12	-0.11	0.09	-0.05		
Dry weight	0.05	0.57	-0.25	0.03	0.13	0.32	
Dry weight	0.10	0.79	0.28	0.39	0.68	-0.16	0.97

0.63, 0.74 and 0.85 significant at 5%, 1% and 0.1%, respectively.

Table 4: Correlation matrix showing relationships between the reflectance, vegetation indices and biomass

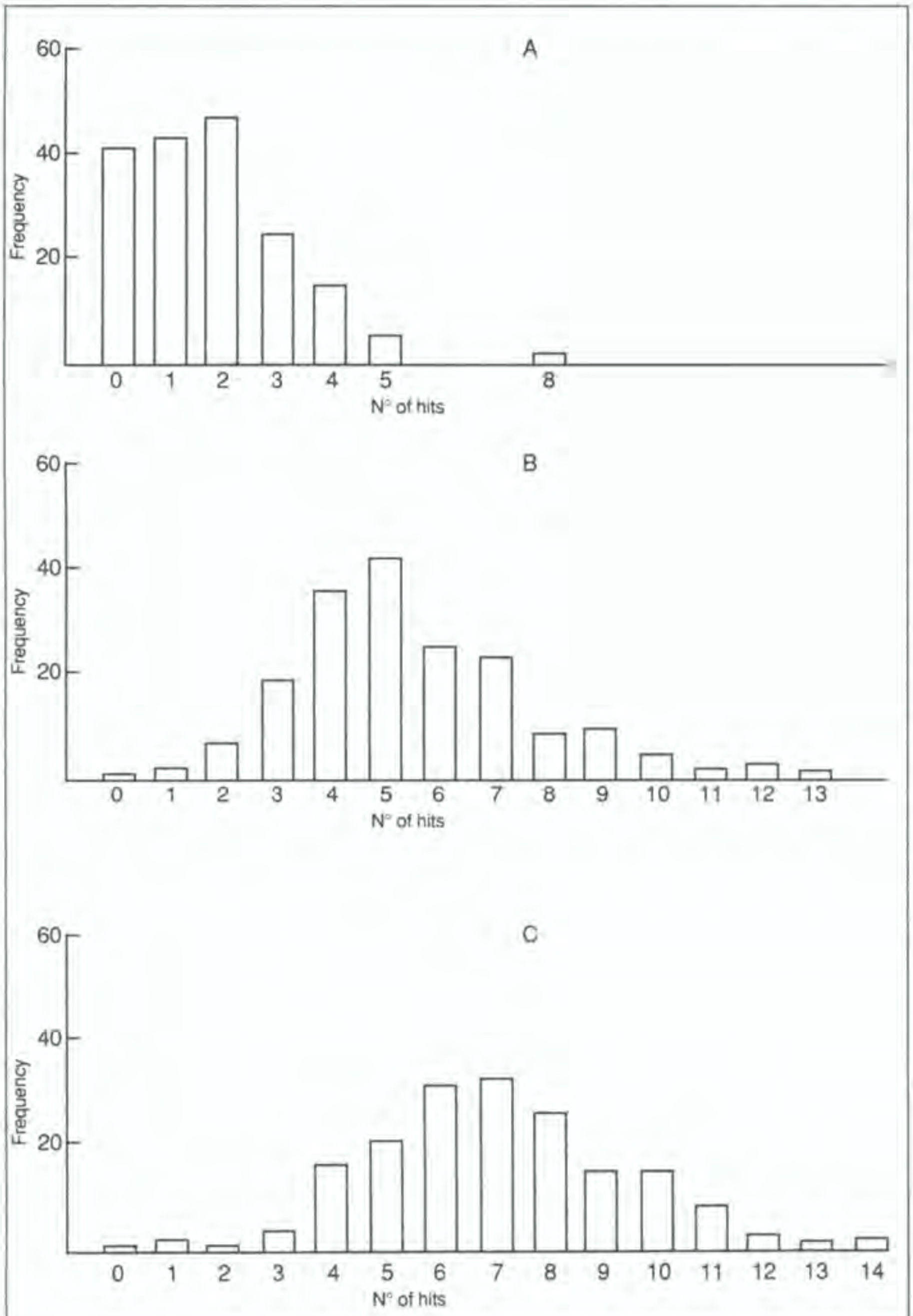

Figure 2: A histogram showing frequency of hits for (A) green and (B) brown and (C) green and brown grasses.

Tables Glossary

NIR	Near Infra-red Reflectance
PVI	Perpendicular Vegetation Index
GLAI	Green Leaf Area Index
BLAI	Brown Leaf Area Index
VR	Vegetation Ratio
NDVI	Normalized Vegetation Index
SBI	Soil Brightness Index
LANS	Long Ashton Nutrient Solution

of PK fertilizer increased the value of NIR reflectance to a significant level. This may be due to the role of potassium in net photosynthesis which resulted in healthier leaves. Neither the application of fertilizer nor its interaction with other treatments produced any significant effect on the NDVI. However, the NIR was significantly increased with both PK and NPK applications which can be put down to the fact that the NIR was found to be sensitive to changes in percent cover beyond those values at which red reflectances became insensitive (Colwell, 1974) due to multiple scattering between leaves of green vegetation.

The application of water on a daily basis resulted in the production of relatively yellowish leaves, largely due to leaching of nutrients. Greener leaves occurred where there was a slight water deficit in pots watered only weekly prior to the first harvest. This accounts for the higher reflectance values in red even though greater biomass was produced in the daily watered pots. At the second harvest, weekly watered pots gave more biomass with corresponding low red values, but the lower NIR values were perhaps due to changes in leaf mesophylls (the changes in intercellular spaces), (Gausman *et al*, 1969). This might be responsible for the rise in the vegetation indices. At the first harvest, there was no correlation between biomass and red reflectance because red was sensitive to the variation in vegetation amount caused by defoliation as red is directly related to efficiency of growth (Steven, 1983). In general, all the spectral parameters shared some sort of relationship with yield in the following order of significance: red, NDVI, VR and NIR.

In the second experiment, the variation of density of green (and brown) vegetation between pots differed significantly, resulting in strange spectral values. After senescence, the variation in the amount of new regrowth resulted in exposure of brown vegetation to the measuring instrument, which is assumed to account for some of the spectral disparities. This is because reflectivity of senesced plants is quantitatively different from healthy green vegetation. Several studies (eg. Drake, 1976) have reported that the presence of dead matter has been noted to 'spoil' correlations between remote sensing measurements and canopy measurements. This causes an underestimation of biomass and an increase in the red reflectance ratio. However, these effects can be corrected if the proportion of dead matter is known (Curran, 1981).

The relationship between NIR reflectance, GLAI and total dry weight are both unexpectedly insignificant. This disagrees with Curran (1981) who worked on pure stands of green leaves. This is attributed to the fact that the total dry weight of brown leaves in each pot was about two times that of green leaves. The larger amount of dead vegetation after regrowth obscured the soil effects and the NIR values remained roughly within the same margin. Also, from the results, the NIR reflectance and the PVI showed a positive relationship with yield, hence a spectral discrimination of green leaves from the background but, in this experiment, did not separate brown from green vegetation. These findings are not in agreement with Kumar (1961) who reported that the spectral reflectance ratio is remarkably invariant with soil types, which is in line with the theory that VR responds directly to chlorophyll content.

The failure of red reflectance to establish a consistent relationship with biomass can be explained by the red's high sensitivity to sandy soil. This could also explain the poor correlation between biomass and the vegetation indices. The problems experienced and the results obtained were expected due to the unique nature of the experiment. They were compounded by the lack of literature on this aspect of remote sensing.

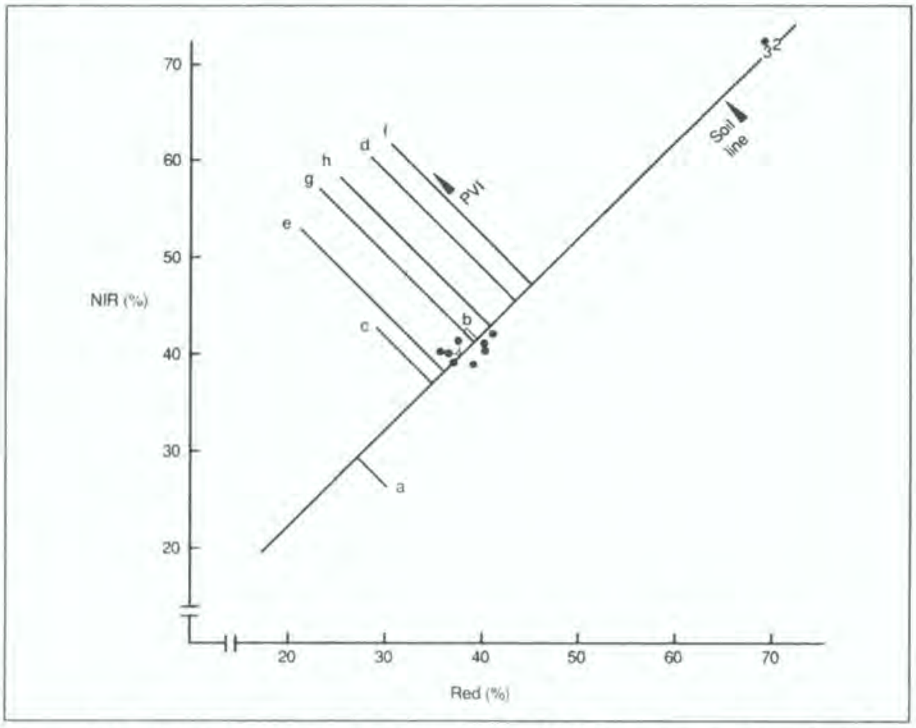

Figure 3: A soil line obtained from means of red and NIR reflectances of moist, wet and dry soils and PVI of grass during the first stage of growth (a = 9 days, b = 16 days, c = 23 days and d = 27 days after planting) and after regrowth (e = 207 days, f = 211 days, g = 214 days and h = 218 days after planting).

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Regional Development and Desertification Control through Ecological Farming: Three Examples in Argentina

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Introduction

About 75% of the land surface in Argentina is arid and semi-arid. In these large areas of low productivity the renewable resources are wrongly managed and desertification processes are taking effect. The only areas where the conditions are favourable for economic growth are in the watered oases (figures 1 and 2). Consequently, there is a marked rural-urban migration towards these oases. However, there is no extra capital to extend urban facilities to cope with this influx and the migrants, who are generally very poor, unemployed and without the means to support even their most basic needs, settle on the outskirts of the city and create impoverished surburban belts.

Besides the social costs, the inadequate management of renewable natural resources (as is evidenced by the indiscriminate felling of trees, overgrazing and use of fire, etc) and very expensive, high-impact foreign technologies (eg, land clearing with heavy machinery, etc) is resulting in the continuous degradation of those resources. For example, among other consequences, the amount of soil lost through water erosion is increasing, and many native species of fauna (many of which may have an unknown, exploitable potential) are disappearing, along with the subsequent loss of genetic diversity.

Many native species produce gum, resin, wax, etc, that meet the present demands of the chemical and pharmacological industries and are also useful for building houses. Other species make good fodder. So it is clear then that there is a need for an effective fight against desertification through the rational use of these resources, mainly through intermediate institutions that should be integrated into the national productive system.

Aedquate technologies are those that are most applicable to local conditions and which do no involve degradation. An adequate technology takes into account the socio-economic reality of a country (Singer, 1978) and aims towards the permanent production of resources, maybe employing intensive manual labour and using local raw materials. Conditions in developing countries such as Argentina call for the use of technology of low capital density and a greater amount of manual labor.

The technological criterion behind eco-farming is that the type of resource and the limiting conditions of the ecosystem are inter-related. So eco-farming demands the identification, selection and assesment (biological and economical) of the native and foreign species that grow and reproduce under specific environmental conditions. In arid regions, due to scarce water for irrigation, the use of low quality water, poor soils (sandy, saline), etc, the construction of rain-water catchment areas and the use of techniques with low technological impact can contribute to an increasing and sustained production of the natural resources.

Eco-farming is then an appropriate technology that permits wide areas that have been degraded by both human and desertification processes to be included in regional or national productive systems.

Three Examples of Eco-farming in the Argentine Arid Zone

Argentina has two sectors that are climatically and economically well defined (figures 1 and 2/page 34).

1. Sub-humid Region

The subhumid-humid region has very fertile soils (with Ustic and Udic soil moisture, and Thermic and Hyperthermic soil temperature regimes), with higher farming and cattle productivity and a high revenue rate.

2. Arid/Semi-Arid Region

The arid/semi-arid region generally has poor soils (with scarce or nill pedogenetic proc-

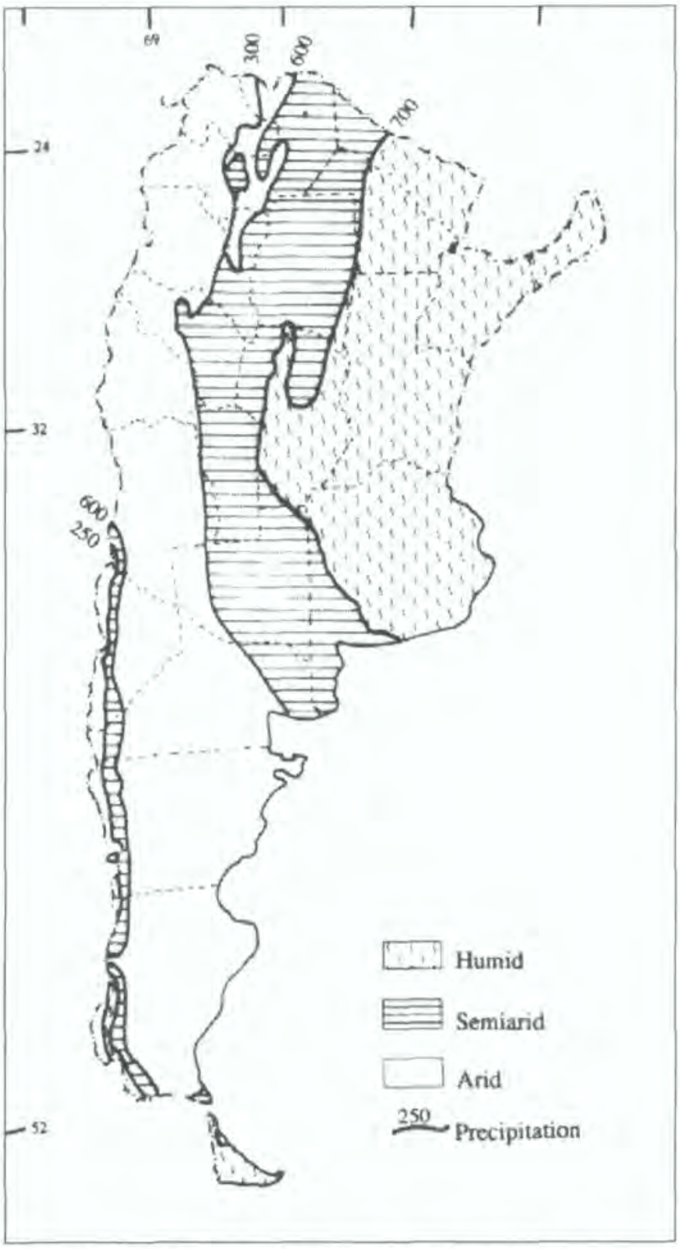

Figure 1: Humid, semi-arid and arid lands in Argentina

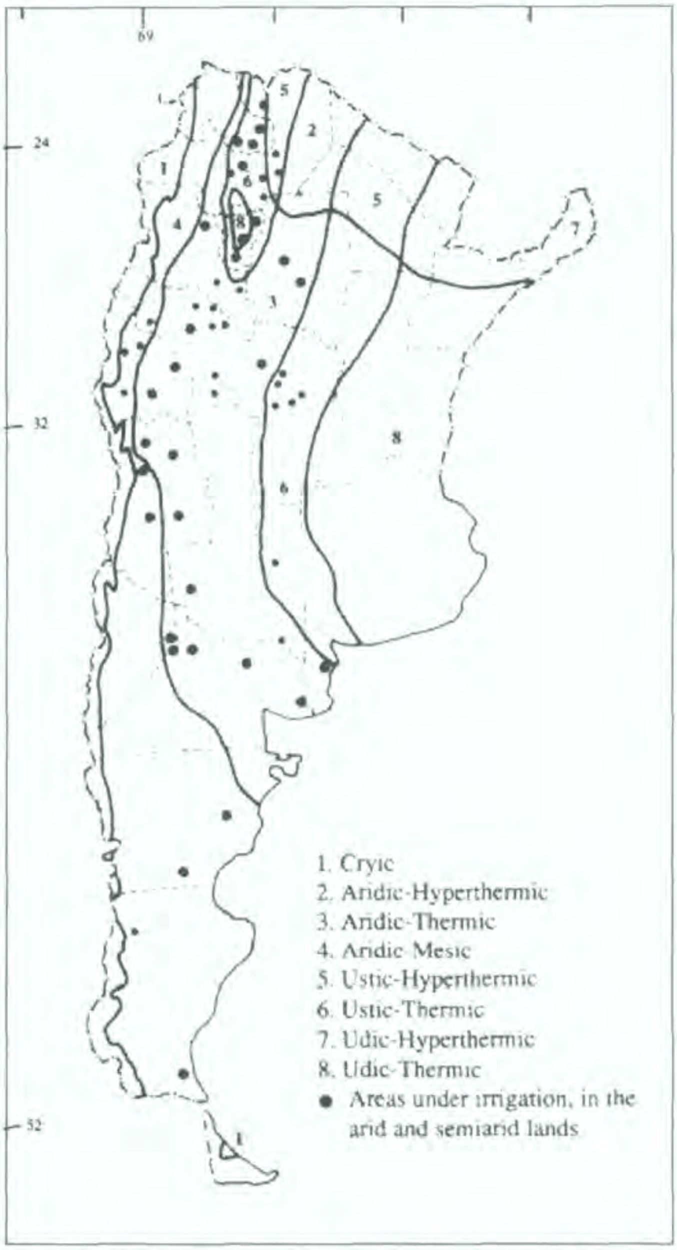

Figure 2: Soil moisture and temperature regimes (iinfromation from differenct sources.

esses, and with Cryic and Aridic soil moisture, and Thermic and Mesic soil temperature regimes) and is a region of low productivity. Consequently, its participation in the productive system is scarce and almost unimportant. The irrigated oases (figure 2) of this sector are an exception since they are economically integrated into the first region. Currently, available information is enough to improve and change the possibilities of the second region.

Of the three examples of ecofarming to be examined, two have an industrial base (Retamo and Chañar brea) and the third is appropriate for livestock (Sorgo).

Retamo Wax

Retamo (*Bulnesia retama* (G. ex H. et A.) Gris., *Zygophyllaceae*) is a shrub 2-3 m high, sometimes reaching 6 m, with a few thick trunks measuring 30-40 cm in diameter). The trunks and young branches are covered with an abundant appressed pubescence that is subsequently replaced by an abundant waxy layer that is white-ish and fragile when it dries. The leaves are ephemeral and the flowers solitary (figure 3). This species lives in the most xeric conditions of Argentina (north of Mendoza and southwest of San Juan, Calingasta, Barreal, Puchuzun, Iglesias and Bermejo) in areas with less than 100 mm of yearly precipitation (normally 25 mm) (photo 1). Propagation is mainly sexual.

Industrial Uses

Presently, and for many years, carnauba wax (*Copernicea Cericea*) has been the most exploited and commercialized wax throughout the world. Retamo wax began to be commercially exploited in 1949 in the province of San Juan. That year the surface area occupied by retamo in Argentina was estimated to be 6,400,000 ha, 2,000,000 of

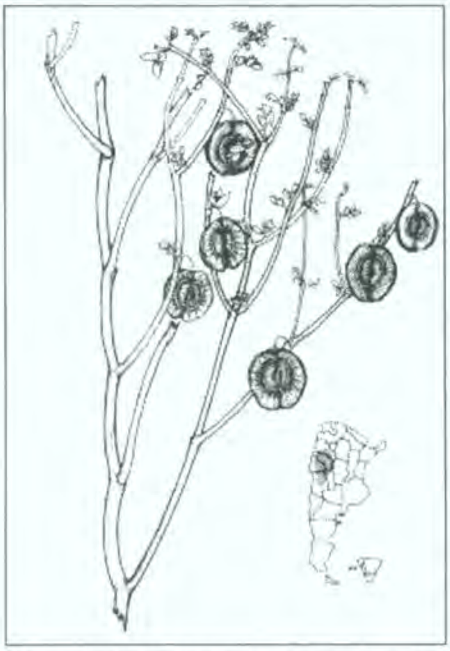

Figure 3: Bulnesia retama(G. ex H. et A.) Gris. *Retamo.*

Photo 1: Thicket of Bulnesia retama *(retamo) in the extremely arid areas of Calingasta and Barreal (San Juan province), Argentina. The plants occupy only the stream-flows where water is more available. Photo: Eduardo Martinez C.*

which belonged to San Juan (Tinto y Pardo, 1957). At present the land surface covered with retamo has decreased notoriously in the province of San Juan due to the uncontrolled exploitation of this species. In 1978, Sattler estimated to be down to 400,000 ha.

Wax production has also varied remarkably: 5 t in 1979, 93 t in 1981, 10 t in 1982 and 67 t in 1983 (IFONA, 1983).

Extraction

According to Tinto y Pardo (1956, 1957), the most traditional method of wax extraction is the *castillo* method. It consists in building stocks and piles of branches on the soil with the thicker trunks facing towards the wind. In this way, the stock will dry due to the high radiation and the hot wind. The branches are then beaten on a canvas and the wax comes easily away. Wax obtained in this way is extremely unclean with mineral impurities.

There is a more rational modified *castillo* technique. In this method the branches are put in metallic containers and dried in *canchas* (drying areas or fields) of variable sizes (100-200 m^2). After 30-40 days the branches are beaten to remove the wax. Next the wax is sifted to remove small branches, stones, etc. One drying area yields approximately 1,200-1,500 kg of wax plus impurities. After several siftings a whitish powder with approximately 78% of wax is obtained (the rest being minerals).

A second variant is the *cerote* method which uses the direct application of hot water to extract the wax. About 250 kg of branches are placed in 2,000-2,500 litre metallic containers which are filled with water and then heated. After one hour the melted wax accumulates on top and, after being cooled, is removed in its solid state. This method yields approximately 35% of wax. The used plant material is dried and then used as fuel. The next step is to separate the wax from the impurities, either by directly melting the wax or by melting it with water. In both cases the wax melts at 80°C. Directly-melted wax yields 75% of fine wax dust with 80-90% of purity. Wax melted in water can be separated by successive decantations or by centrifugation which yields an opaque yellow dust that is 99% pure. The average yield of wax per branch is 2-4%. The young branches, with diameters of 1-2 cm, contain more wax; the older branches loose it totally. Although there are no specific studies, Sattler (1978) advises that plants should be pruned as follows: in old and tall plants to clear-cut at 0.5-0.6 m; in old plants of normal size and abundant young branches, to cut 50% the first year, every five years. About 5-10 % of trees for seed should be left in each case.

Wax Uses

The wax is used for shoe polish, floor polish, publishing, carbon paper, varnishing, lithography, adhesives, plastic, pencils, etc.

Gum from Chañar Brea

The chañar brea (*Cercidium praecox* (Ruiz et Pav) Harms., Leguminosae) is a shrub or small tree with winding branches, polished green bark and generally solitary thorns (figure 4). The leaves are small, deciduous, bi-pinnate, and generally solitary. The corymbate flowers are yellowish and the fruit is a flat pod.

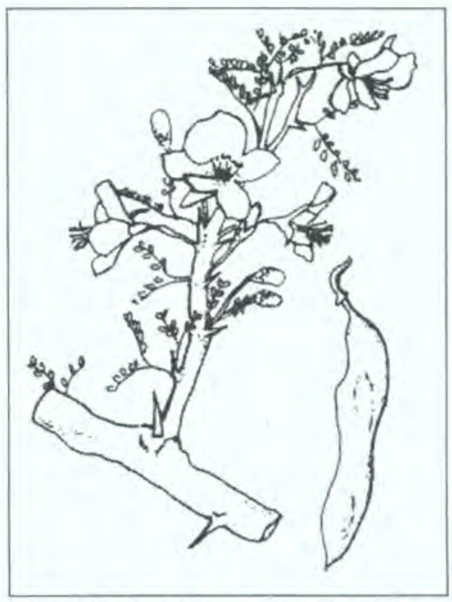

Figure 4: Cercidium praecox *(Ruiz et Pav.) Harms.* Chañar.

There are two subspecies: the tree-like *Cercidium praecox* subsp. *praecox*, which belongs to the phytogeographic province of Chaco (this subspecies can also be found in northern Peru, in the Piura desert); and the shrub-like *C. praecox* subsp. *glaucum*, which is distributed only within the phytogeographic province of the Monte (Martinez Carretero, 1986).

The gum regularly oozes from the plant as a defense against wounds, attacks by insects, etc. The subspecies *praecox* has greater gum yield and is consequently more interesting, commercially.

Gum Extraction

As early as 1905, the gum from this plant was known to be economically attractive and of great interest, commercially. From December to April the trunk secretes a more or less abundant gummy substance called *brea*, hence the plant's common name. This secretion can be stimulated through incisions in the bark without affecting the sapwood. The incisions are made both in the trunk in the branches. As the gum comes into contact with the air it solidifies so the plants have to be cared for daily, both to remove the gum and to keep the secretion active. If the gum is not removed in approximately 15 days the wound heals and secretion stops. The gum starts oozing between the first and the third day after the incision was made. After about 12 days' collection, the plant will have yielded between 300-400 g of gum.

Gum Composition

As in any other vegetal gum, the chemical composition of chañar brea gum is very complex. It is made up of polyholosides which, through hydrolysis, give pentoses (*L. arabinose*), hexoses (*D. galactose*) and hexuronic acid (glucuronic acid). According to Bianchi (1972), the gum contains: 16% water, 66% gummic acid, 44% ash (Ca, K, Mg, Fe, Si, C_1, CO_3) and 1% insoluble residue. The gum is very soluble in water and of acid reaction. Table 1 shows the comparison between brea gum and other useful gums. Table 2 shows some important physicochemical values.

Use of the Gum

During many years the gum from chañar brea was used as glue by post-offices. It is presently in great demand by the pharmacological industry (for capsules, coating, etc) and by the food industry. When the proportion of gum is 1:6 (1 gum : 6 pulp) it can successfully replace Arabic gum.

Reactive	Arabic gum	Tragacanth gum	Chañar brea gum
Tanic Acid 10% solution	negative	negative	becomes muddy
Lead boric acetate (AOAC)	white precipitate	white precipitate	voluminous precipitate
Concentrated SO_4H_2	Negative	Negative	Negative
HOK at 10%	solution turns yellow	yellow precipitate	solution becomes yellow
Schiff reactive	Negative	Negative	Negative
Alcohol 96%	Very fine non-adherent flocculus	fibrous clots	very fine flocculus

Table 1: Chemical comparison of chañar brea gum and other usual industrial gums (according to Bianchi, 1972)

Figure 5: Sorgum alum *Parodi* Sorgi.

Specific weight	0.985
Acidity Index	49.1
Iodine Index	4.9
Saponinification Index	87.9
Fusion Point	76-7°C
Solubility in Acetone	2.5-3%
Compatibility with other waxes	complete
Hardening	quick
Brightness in film	regular

Table 2: Physicochemical values of the chañar brea gum (according to Tinto y Pardo, 1957)

Sorghum

The *Sorghum almum* (L.R. Parodi, *Gramineae*), which originated in Argentina, is a perennial, rhizomatous, stoloniferous grass, with pubescent nodes and long and pyramidal panicles (figure 5). It grows between 1.8-2.5 m tall (sometimes 3 m). The rhizomes curve upward, sending out shoots from mid-December. It is less aggressive than its parent *Sorghum halepensis*. It blooms from December to April (summer-autumn). According to Parodi (1957), it is apparently a hybrid of two sections: subsection Halepensia (*Sorghum halepensis*) and subsection Arundinaceae.

This species is cultivated only in non-irrigated dry lands in the arid zone of Argentina as rainfed crops, though it can be cultivated under irrigation. It usually requires between 450-700 mm of precipitation per year. Of the cultivated fodder in the Llanos (La Rioja province) it is the most widespread and adapted to aridity. With bad management, its cultivation lasts approximately 3-5 years. It is advised that it should be sown in separated rows, 15-30 cm apart, with about 0.5-2 kg/ha of seeds. It starts to grow in spring after the first rains

The community of Bulnesia retama *in the piedmont of the Calingasta area (San Juan). The retamo is the only dominant species in wide areas of the territory. Photo: Eduardo Martinez C.*

and with mean temperatures of 1-14° C.

It is more or less toxic as it contains dhurrin, a cyanogenetic glucoside (HCN). It cannot be grazed when it forms stalks or with insufficient development because toxicity increases. Values between 0.06 and 0.08 percent of HCN in plants have been reported by Skerman and Riveros (1990). It is normal to graze it when it is 0.6-0.8 m tall. In our arid zone, it is commonly used as cut fodder. It is one of the most valuable summer fodder resources in the semi-arid and sub-humid zones (Skerman and Riveros, 1990). In La Rioja, the foot of the peidmont is used for its cultivation, where rainfall runs off as a sheet. The only adquate management is to avoid the concentrated run-off that forms erosion stream-flows in the cultivated field. When this happens the crop deteriorates rapidly and it is invaded by the species belonging to the natural, stable plant community, where the culture was installed.

Conclusions

The arid zone of Argentina shows significant possibilities for becoming part of the productive-commercial system through the use of appropriate technologies. Moreover, the rational management of arid land natural resources will contribute to the control of soil erosion (hydric and aeolic) and of desertification processes. Planning policies for these natural resources will also allow for a suitable ordination and occupation of the territories. In botanical terms, most of these territories are yet to be throughly and properly explored so the potential value of their native flora is high. Numerous species of pharmacological, nutritional, industrial, ornamental, etc, interest still need to be studied and commercially appraised.

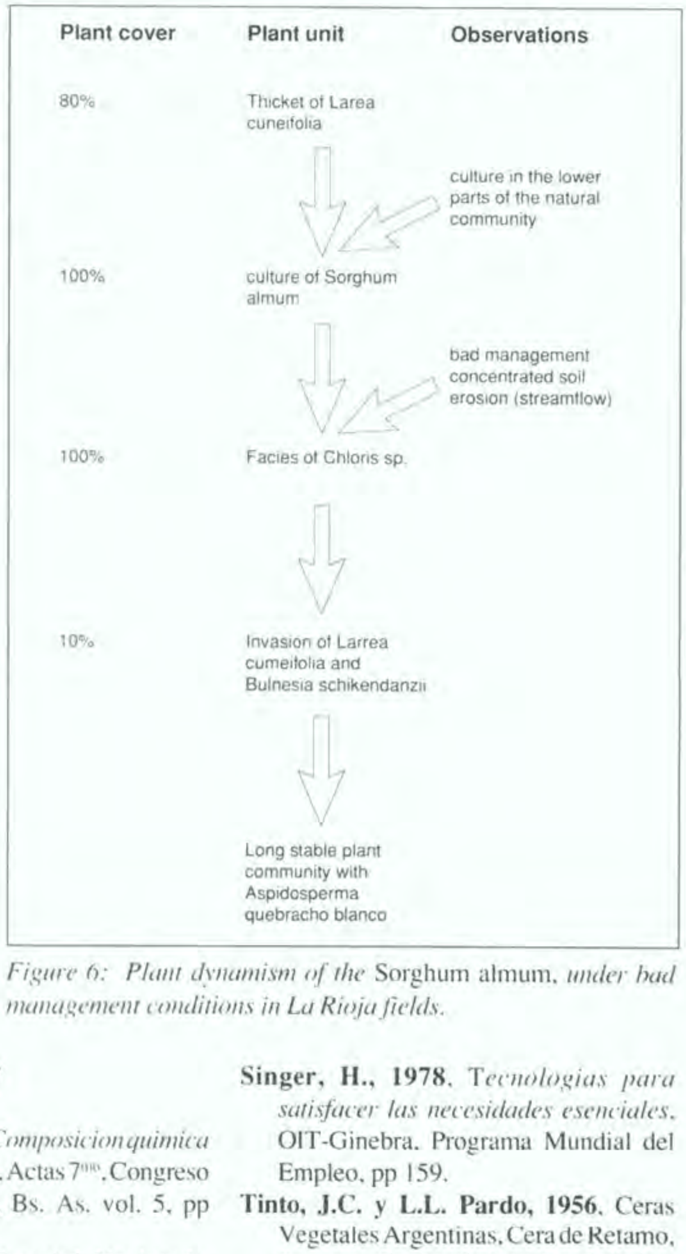

Figure 6: Plant dynamism of the Sorghum almum, *under bad management conditions in La Rioja fields.*

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Sustainable Development in Wadi Allaqi

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Land Use in Egypt

The total land area of Egypt is 99,545,000 hectares, of which 96,943,000 hectares is desert. The arable area is 2,571,000 hectares, showing an increase of 1.2% over the decade ending 1989 (World Resources, 1992).

Developing water resources and reclaiming land have long been important components of Egypt's agricultural strategy. Since the 1952 revolution over $3.0 billion have been expended on land reclamation and some 1.6 million feddans of land reclaimed for agricultural use (World Bank Report, 1990).

Only 3.15% of the land surface is cultivated, mostly in the Nile valley or delta, and much of this is already being cultivated at near maximum levels of intensity. With a population of 52.43 million, growing at 2.39% per annum, the Egyptian Government is facing an increasing food supply crisis. Egypt is currently importing foodstuffs to the value of about $3 billion, and bringing new land into production is a priority for the Government. The Lake Nasser shorelands offer an alternative to the current Nile delta land reclamation programme.

Development

There is, however, a locational difficulty in that these potential production areas are at considerable distances from the main population centres in the north of Egypt. The absence of good transportation inhibits exploration of the area. Only recently was the road on the western side of the Lake completed and the road on the eastern side is still under construction. A further difficulty lies in employing appropriate agricultural technology, particularly in establishing a suitable irrigation system. But the key problem is that the location of the lakeshore is constantly changing in response to the balance between lake inflows and outflows. There is always the danger that the land in which capital investment was made on any major scale would be either flooded, or left at considerable distance from sources of usable water.

At present, there appear to be four main interest groups involved. The state, represented by the Aswan High Dam Lake Development Authority (AHDLDA) and, to some extent, the Ministry of Agriculture, has clear interests. Private capital is a second interest group. However, there is the problem that private capital sees the Lake Nasser shorelands as representing a high degree of investment risk. Third is the bedouin group already living close to the shores of the Lake. Fourth, the Nubians who were living in this area before inundation by the Lake have a great interest in being resettled on their mother lands.

There is little doubt that the economic opportunities produced by inundation around the Lake Nasser shorelands have increased considerably over the last 15 years. However several factors have combined limit to limit the success of reclamation efforts. These include:

(1) lack of knowledge of the environmental factors affecting the marginal zone, particularly the duration and extension of the flood;
(2) lack of a production technology adapted to the peculiarities of the desert environment;
(3) weak post-implementation assistance including extension, training and input supplies. Because of this, lands which were not fully reclaimed/developed have been cultivated and an inappropriate deltaic land technology has been applied to the desert soil.

Following the recommendations given in the World Bank Report (1990) there is a continued need for traditional research in:

(1) irrigation methodologies,
(2) crop water requirements
(3) fertilizer requirements
(4) cropping systems particularly those applicable to desert soil. Research to adapt new technologies to the local environment is necessary to fully exploit productivity potentials.

Although several studies have been carried out in the Aswan region as a result of the building of the High Dam, there are still wide gaps in our knowledge about how the harsh desert conditions affect life in this hyper-arid environment. The creation of the High Dam (Nasser) Lake has brought about unusual conditions of permanent water availability at its shores, yet this favourable situation remains relatively unexploited (Supreme Council Report, 1989), wasting a great potential resource.

Several integrated development schemes can be envisaged for these shores, extending for more than 13,000 km on both sides of the lake. In addition to the lake shores are the mouths of wadis into which the lake waters penetrate and recede according to the rise and fall of water level in the lake, which is controlled by incoming flood water on one hand and the draw down for the needs of the rest of Egypt on the other hand. Integrated development schemes should comprise agriculture, small industries, animal husbandry, tourism, etc. but in a harmonious, environmentally sound and socially acceptable manner, and for the benefit of the local population.

A Symposium on the Environmental Development of the Desert of Aswan Governorates was held in Aswan in December 1988 and concluded that the development potential of these deserts is considerable, provided that certain precautions are taken and that limitations are recognized (Environmental Development of Aswan Desert, 1988).

Aswan High Dam - Effects and Implications

The construction of the Aswan High Dam, which was completed in 1971 and was one of the first 'super dams' to be built, has provided Egypt with an enormous water storage capacity reservoir. The great man-made lake extends to the south of Aswan for about 500 km, of which 200 km are in Sudan (figure 1). The largest part of the lake within Egypt is known as Lake Nasser; the part in Sudan is known as Lake Nubia. The water of the lake has covered the whole Nubian Nile Valley and deeply penetrated into the desert through the desert dry rivers (wadis). Depending on the quantity of water stored in the reservoir, its shoreline bounds 5,300 to 7,800 km of desert land (White, 1987), which is subjected to periodic flooding.

On the margin of the desert and the lake a new ecosystem has replaced the previous extremely arid ecosystem, lake water fluctuation being the main factor affecting this marginal ecosystem. Because of the shallow gradient of the lake shores, especially where the wadis join the lake, and variations in the amount of water feeding the lake from the upstream Nile basin, fluctuations of the water level can vary by as much as 30 m, resulting in several km lateral movement of water within the desert and particularly along the wadis.

The annual variations cause the shoreline to move by a few km; the long-term fluctuations have resulted in changes of the order of tens of km. These alternating periods of flooding and exposure prevent permanent cultivation of the marginal zone. It is now subject to natural seasonal vegetation, in contrast to the former narrow ribbon of land along the river under continuous cultivation.

Figure 1: Location Map

Wild animals were attracted to this expanded shore, and the availability of herbs for grazing close to fresh water likewise attracted nomads in the eastern desert area who began to alter their patterns of seasonal movement in order to take advantage of the enlarged grazing and year-round access to water (Fahim 1979, Briggs *et al* 1992), as well as to grow crops on a limited scale (Pulford *et al* 1992). Their former migration patterns were disrupted, and they began to congregate in more permanent settlements on the lake shore (White 1988, Belal *et al* 1992), threatening to unbalance human/resource ratios. This is specially serious where the population lives in the marginal environment.

At the outset there were hopes that agriculture might be established along the fluctuating reservoir shore, with farmers taking advantages of the recession from periodic inundations. Pilot plots with that aim were established near Abu Simbel but the huge fluctuations in water level discouraged any substantial development (White, 1988). The situation seems to have improved in more recent years. A FAO project, implemented about three years ago, is doing well. The fact that the annual water fluctuations of the Lake were stable during this period (see figure 2 / page 40) could have been a factor contributing to its success.

This marginal zone offers considerable economic potential, taking into account the prolonged period of vegetation growth, the wide range of effective temperature nearest to the water source and silt deposition which contribute to the soil fertility. However, reclamation of this zone is a complicated process due to the high instability and vulnerability of this newly formed ecosystem, severe climatic conditions, large fluctuations of water level in the lake and the scarcity of human population in the area. Recommendations for reclamation of this area will be different from those in other parts of Egypt, especially taking into consideration that the Aswan High Dam Lake is the single source of water supply for all Egypt and any actions must be based on conservation of the quality and quantity of the water in the lake.

The Allaqi Project

Sustainable development of the area around the lake is a long-term continuous process which needs specialists of different skills in the natural and social sciences to assess the nature and suitability of the natural resource base for sustainable economic development. The Faculty of Science in Aswan, a branch of Assiut University, has demonstrated its commitment to sustainable development. The downstream part of Wadi Allaqi was selected for implementation of a pilot project (Wadi Allaqi Project).

This area has great possibilities for reclaiming and developing these untapped resources for the benefit of the local inhabitants and also for the Nubians who would like to return to their old environment (they were relocated to Kom Ombo, or New Nubia, about 60 km north of Aswan, when the High Dam was being built during the 1960s).

The research work in Wadi Allaqi is implemented by the Allaqi Project team. A comprehensive and systematic research programme, including field and laboratory work, together with field trials and experiments in Allaqi, is being conducted. The Allaqi Project began in 1988 as a multi-disciplinary Project involving different departments of the Faculty of Science.

Research has been funded since 1988 to date by UNEP and supported by the British Council. The successful implementation of the Project attracted the interest and financial support of other organizations such as DANIDA, the Supreme Council of Universities, International Development Research Centre (IDRC) Ottawa, Canada, etc.

Aims of the project include:

(1) to contribute to scientific knowledge and understanding of the environment around Lake Nasser,

(2) to determine the suitability of Wadi Allaqi for sustainable agricultural and other economic development and for human settlement by:

- assessing the flora, fauna, soil, water, mineral and energy resources (phase 1),
- establishing an experimental farm and pilot demonstration area (phase 2),
- making a cost-benefit analysis of the development of the area, and preparing preliminary models for the development of both Wadi Allaqi and Aswan Dam lake region as a whole (phase 3).

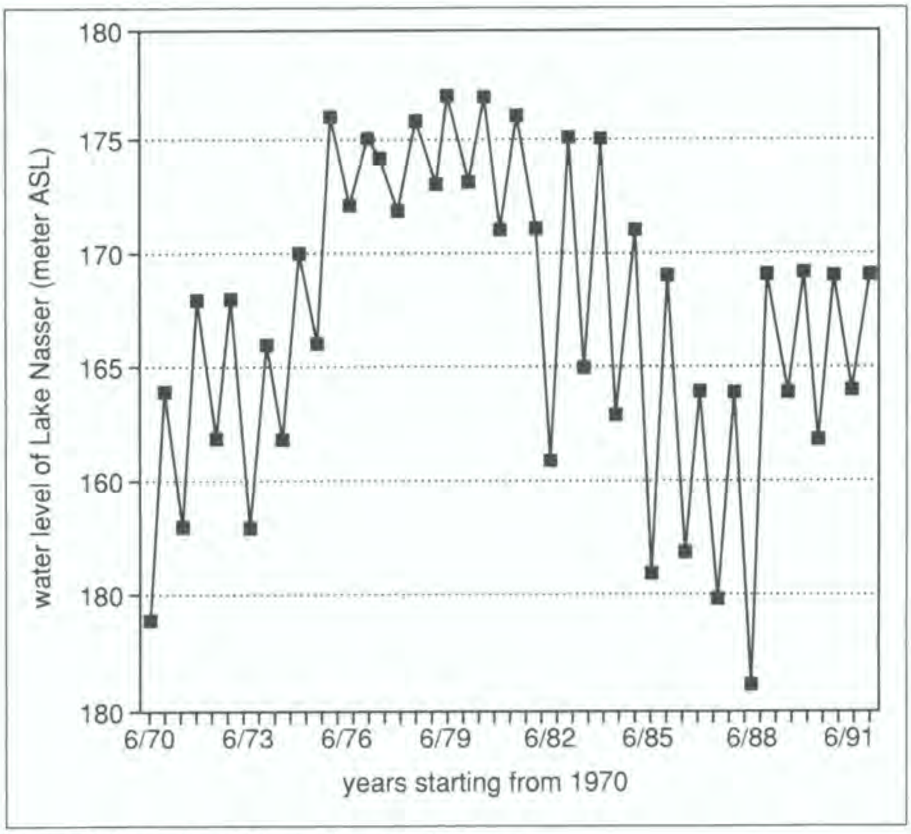

Figure 2: Water Level Fluctuation of Lake Nasser

Wadi Allaqi - Description of the Area

Wadi Allaqi lies on the eastern side of Lake Nasser between latitude 22°00' and 23°00' North and longitude 31°01' and 32°80' East (figure 1). Wadi Allaqi is a major 'dry river' which drains from the Red Sea hills to the Nile Valley in Southern Egypt. When the Aswan High Dam was built and Lake Nasser filled in 1967-72, water entered the mouth of the Wadi which became part of the Lake. About 80 km of the Wadi was inundated and remained under water for several years. When the level of the Lake fell in the 1980s, the water receded some 40 km from the Wadi, leaving a deposit of silt on the exposed wadi bed where extensive groves of tamarisk shrubs established themselves and a new ecosystem developed (Springuel and Ali 1990).

Briggs *et al* (1992) described the area as follows: 'Throughout its lower 40 km Wadi Allaqi is flat-floored. This valley bottom is composed of unconsolidated wadi sediments, chiefly laid down in the early Holocene when the local climate was wetter. It has a very gentle average gradient of 0.5°, and the floor is from 0.75 to 3 km in width.'

Although not at present an important factor in the overall soil properties of the wadi, wind-blown material could become significant if development in the wadi results in degradation of the soil. This is probable in view of the sandy texture of the soil and the low amount of organic matter. Wind-blown soil could collect around cultivated plots and trees, causing damage or killing plants. Thus any development in the wadi must include practices which avoid physical degradation of the soil.

Perhaps of greatest effect on soil quality is the influence of lake water on soil properties. There are parts of the wadi which are seldom inundated, parts which are frequently inundated and parts which are usually inundated. As a result of this variation, many of the soils within the wadi have been influenced by the lake water during the last

20 years. There are two processes which are important: the deposition of silt from the lake water during inundation; and changes in the chemistry of the surface soil layers during and immediately following inundation. Flooding by lake water has resulted in chemical reduction in the surface layers. The tamarisk litter has an important effect on surface soils as it accumulates salts (Briggs *et al* 1992).

Ethnically, Wadi Allaqi comprises two groups of which 89.5 per cent of the population are of Abadi origin (Mohamed *et al*. 1991). Since inundation a second ethnic group, the Bishari, has settled there. As yet, there have been no major land disputes in the wadi, primarily because the population/resource ratio has not been threatened. But if more nomads continue to settle in the wadi, this may become a pressing issue. At present the population of Wadi Allaqi is 218 which is twice that of the preinundation 1960s. The people of Wadi Allaqi do not consider themselves to be fully settled. Movements are taking place within the wadi itself, albeit very much on a local scale, but entailing the re-location of settlements and cultivated plots.

The environmental variables of greatest influence on seasonal economic activity are: the monthly variations in the level of Lake Nasser; the incidence of winter rainfall in the hills to the south and east; and air temperature.

The five main components of the economic system are: livestock transhumance, charcoal production, cultivation, *dabuka* (camel trains) transits and the collection of medicinal herbs (Mekki and Briggs, 1991). Cultivation is a summer activity, carried out between April and September. The exact timing of planting is largely determined by the rate at which the lake recedes at this time of year (shore-line irrigation). Livestock transhumance and charcoal-making dominate the winter half of the agricultural calendar. The keeping of livestock is central to the economy of households in Wadi Allaqi. Sheep and camels dominate although there is a small but significant number of goats.

Wadi Allaqi is a major stopping-point for *dabuka* coming from Sudan. The available water in Wadi Allaqi is vitally important for the maintenance of camels. It is estimated that more than 100,000 camels per annum make the journey from Sudan to Aswan by this route.

Sustainable Development in Wadi Allaqi

Wadi Allaqi was declared a conservation area in 1989 and its sustainable development in a conservation context should include certain strategies, including:

1 The creation of woodlot plantations as an alternative to the exploitation of wild trees. The plantation will provide for fuelwood and building materials. This may be possible in parts of the Wadi Allaqi region.
2 The cultivation of economically important and ecologically suitable plants, complementing protective conservation measures by increasing the productivity of natural vegetation. In this way both conservation and human needs could be satisfied.
3 The cultivation of medicinal plants could provide the key to solving the problem of which kinds of crops should be cultivated in the area around Lake Nasser. At present it is a serious problem as the majority of cultivated plants are immediately eaten and destroyed by birds. A number of projects to protect the cultivated fields (including poisoning birds) have failed.

Temporal cultivation is possible in the marginal zone if carefully designed land use management is applied to sustainable development of this area. This is particularly true in the part of the wadi which is periodically inundated as the water stored in the surface deposits is not sufficient for plant growth, hence only irrigated cultivation can be applied in this area. Cultivation of deeply rooted trees and shrubs that could be self dependent after the irrigation is withdrawn is advised in this area. In the annually inundated areas the amount of water stored in the soil is sufficient for ephemeral cultivation without irrigation, if the crops are carefully selected. Annual plants with a short life cycle are recommended for cultivation in this area (Springuel *et al* 1992).

The purpose of the Wadi Allaqi project is to extend sustainable development options for Wadi Allaqi to include the use of energy by local people and by others who are passing through or are exploiting the resources of the wadi. Thus, the specific focus of this work is on sources and use of fuelwood and charcoal (the only two forms of energy available in the wadi) and sources and conservation of medicinal plants. It is also an integral part of the environmental management and socio-economic development plan of Wadi Allaqi and more broadly for the entire borders of Lake Nasser. It should be noted therefore that a balance will be maintained between the energy needs of the resident and transient community and exploitation of the natural resources and between the collection of indigenous plants by the nomads and their cultivation to ensure that over-use does not occur, in accordance with its designation as a conservation area.

To help the local people to establish temporal cultivation in the marginal zone and supply them with good quality drinking water, a small wells project was initiated and is being implemented by the Allaqi Project. It is being funded by the Royal Netherlands Embassy and aims to help Wadi Allaqi residents to establish two wells.

Main Achievements to Date

The main activities and achievements of the Allaqi Project team are:

- the creation of a multi-disciplinary international team interested and competent in research related to the severe dry conditions of remote desert areas and in applying their expertise to broader environmental issues;
- provision of research facilities for local students abroad and for overseas students in Wadi Allaqi;
- training at advanced level for more than 12 students on subjects within the project;
- studying of factors affecting soil fertility, soil chemistry in general, and nitrogen fixation under unusual desert conditions;
- studying of plant ecology, including plant population dynamics, ecology of economically important plants, soil seed banks, etc;
- establishing guiding principles for conservation and management resources, flora and fauna, and devising an inventory of possibilities for

new and renewable energy;
- providing valuable training for young scientists who, it is hoped, will build a solid scientific base in this part of Egypt;
- setting up a specialized laboratory on the faculty campus and a field station in Wadi Allaqi.

As a result of our efforts Wadi Allaqi was declared a conservation area by Prime Minister's Decree in 1989 and is being considered as a Biosphere Reserve within the Man And the Biosphere project of UNESCO. Moreover, Wadi Allaqi has been designated a village within the system of local government.

Some of the initial findings of the investigators are recorded in Allaqi Project Working Papers. They are produced at the University of Glasgow and are jointly edited by British and Egyptian specialists. 17 Working Papers and the Proceedings of Environmental Management of African Arid Lands (EMAAL) conference have been produced so far.

It could be concluded that this multidisciplinary and international study is directed towards the integration and application of scientific knowledge to a problem of great human and development significance. The research programme in the Wadi Allaqi and Lake Nasser area has considerable implications for similar areas in arid and semiarid regions where large scale reservoir impoundment schemes have created a new resource base for shore-line development.


Common view of the downstream part of Wadi Allaqii, densely covered by tamarisk shrubs.

Acknowledgements

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Desertification in Northern Ghana

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This paper discusses the problem of desertification or land degradation resulting from human activities in the dry sub-humid savannah regions of northern Ghana.

The earlier sections describe the physical environment of the area (geological formations, surface relief features, vegetation, climate and soils). It points out that the soils are sandy by nature which is the fundamental reason why they are liable to erosion, leaching and degradation.

The results of field observations in 1987 by a nine-member team on lands/soils degradation are presented, using field procedures (*Structured Informed Opinion Analysis*) similar to Dregne's (1988). It is concluded that between 60 to 70% of the land of northern Ghana is faced with various intensities of desertification hazards. Causes of desertification in the area and suggestions for protecting the soils from further degradation are examined in the final sections of the paper.

Introduction

Reports on the extreme north-eastern corner of Ghana describe the vegetation of the area as 'well wooded' six to nine decades ago. The few protected areas where the vegetation is still in its original state, such as traditional groves, forest reserves and uninhabited areas, confirm these early reports on the richness of the original vegetation of northern Ghana.

Today, much of the natural vegetation is gone as the land has been transformed into degraded, desert-like landscapes where sheet and gully erosion largely induced by man have succeeded in reducing the productive potential of the soil to negligible levels. What really happened - what peculiar local factors succeeded in accelerating the process of desertification in northern Ghana at such an unprecedented rate? Can the further spread of land degradation be prevented so that the ecological balance can be restored?

In an attempt to find answers to these questions, two field trips were organised in 1987 (Ghana Forestry Commission, fact finding mission on the state of the forest cover in northern Ghana, 1-14 July 1987) and 1991 (Department of Geography and Resource Development, University of Ghana, Legon, Socio-economic survey of the Upper East region, Ghana, 22-29 September 1991). The aim was to make field observations of the degraded lands.

Northern Ghana consists of the three administrative regions of Ghana north of the 8°N parallel, namely the Upper-East, Upper-West and Northern Regions (figure 1 / page 44). Roughly square in shape, northern Ghana covers an area of about 98,000 km² (37,800 square miles or roughly 40% of Ghana) and extends between longitudes 0° 30' East and 03° 00' West and from latitude 8° 30' North to 11° 00 North.

The geology of northern Ghana may be divided into three main groups, namely, the areas covered by granitic rocks to the north-west, those covered by shales and sandstones to the south-east; and the areas of metamorphic rocks between the two[1].

The surface relief is generally flat or gently rolling with most slopes usually less than 2%, and an elevation of between 200 and 300 m above sea level (Dickson and Benneh, 1988).

This generally flat terrain prevents the formation of 'remarkable gullies', making sheet erosion the dominant form of soil degradation in the area.

The original vegetation of northern Ghana is described by Taylor (1952) as savannah woodland. This consisted of short deciduous trees often widely space and a ground flora composed of different species of grasses of varying heights.

As a result of long settlement, over-population, annual and periodic fires and other human activities very little of the original natural vegetation remains and a degraded form of tree savannah is what now exists in many places. In the extreme north-east corner where the pressures due to human activities are greatest, the original vegetation has been replaced by the Sudan savannah vegetation, an open parkland with short grasses and dwarfish trees. The common trees include *Lophira*, *Anogeisus*, *Detarium* and *Acacia*. Two particular trees, the shea tree (*Butyrosperum Parkia*) and Dawadawa (*Parkia Filicodea*), are of much economic importance.

The climate of northern Ghana alternates between distinctly wet and dry seasons of approximately six months each. The different seasons are due to the influence of the different air masses which affect the area, namely, the dry Harmattan or north-east trade winds from the Sahara desert (January) and the moist south-west monsoon from the south Atlantic ocean. Temperatures are high throughout the year. Highest temperatures of between 28-30°C occur in March, April or even May. The

1 - In Ghana, the shales and sandstones and associated soils are given the name Volvatain because they are mainly found in the Volta basin. Similarly, the metamorphic rocks are locally known as Birrimian rocks since they are associated with the basin of the Birim river.

mean annual maximum temperature consistently exceeds 30°C.

Soils of northern Ghana have developed over four major parent materials (PM), namely, granitic rocks; sandstones and shale (or Voltaian rocks); metamorphic (or Birrimian) rocks; and various alluvia of mixed origin. In Ghana, the shales and sandstones and associated soils are given the name Voltaian because they are mainly found in the Volta basin. Similarly, the metamorphic rocks are locally known as Birrimian rocks since they are associated with the basin of the Birrim River.

Soils developed over granites are the most widespread and cover an estimated 45% of the total land area of northern Ghana. The second most widespread are the soils that developed over Voltaian rocks (30%). Soils developed over Birrimian rocks account for 20% and the alluvial soils for 5% (figure 2).

Formal investigation of these soils by the Ghana Soil Research Institute (Adu, 1969) show that most of them have very similar characteristics, which include the following:

- Low organic matter (OM) content, usually of less than 2%;
- High proportion of particles in the sand textural grades;
- Shallow top soils;
- Low nutrient status with pH of between 5.0 and 8.0; and
- High vulnerability of erosion.

The lower accumulation of organic matter usually of less than 2% (Adu, 1969) is due mainly to the high temperatures which result in a rapid rate of decomposition, and to the annual burning of the vegetation cover which is practiced widely throughout the area.

A great majority of the soils are sandy by nature, the A-horizons varying in texture from coarse sands to loams. The subsoils (B horizons) on the other hand, tend to be heavier, varying from coarse sandy loams to clays, with variable amounts of gravel.

The top soils are relatively shallow, varying in thickness from between 6-25 cm generally. Sometimes a distinct 'gravel layer' is found inbetween the shallow top soil and the clay layer. In cultivated areas, erosion may expose the gravel layer.

Adu (*op cit*) has explained that owing to the sandy nature of a great majority of the soils, internal drainage is rapid. The top soil and sub-soil dry out quickly during dry spells, which increases the risks in agriculture. The enhanced internal drainage also leads to the development of ground water laterites and to pronounced leaching in many of the soils. The soils thus tend to be poorer in fertility and deficient in many of the basic soil nutrients, particularly phosphorus and nitrogen.

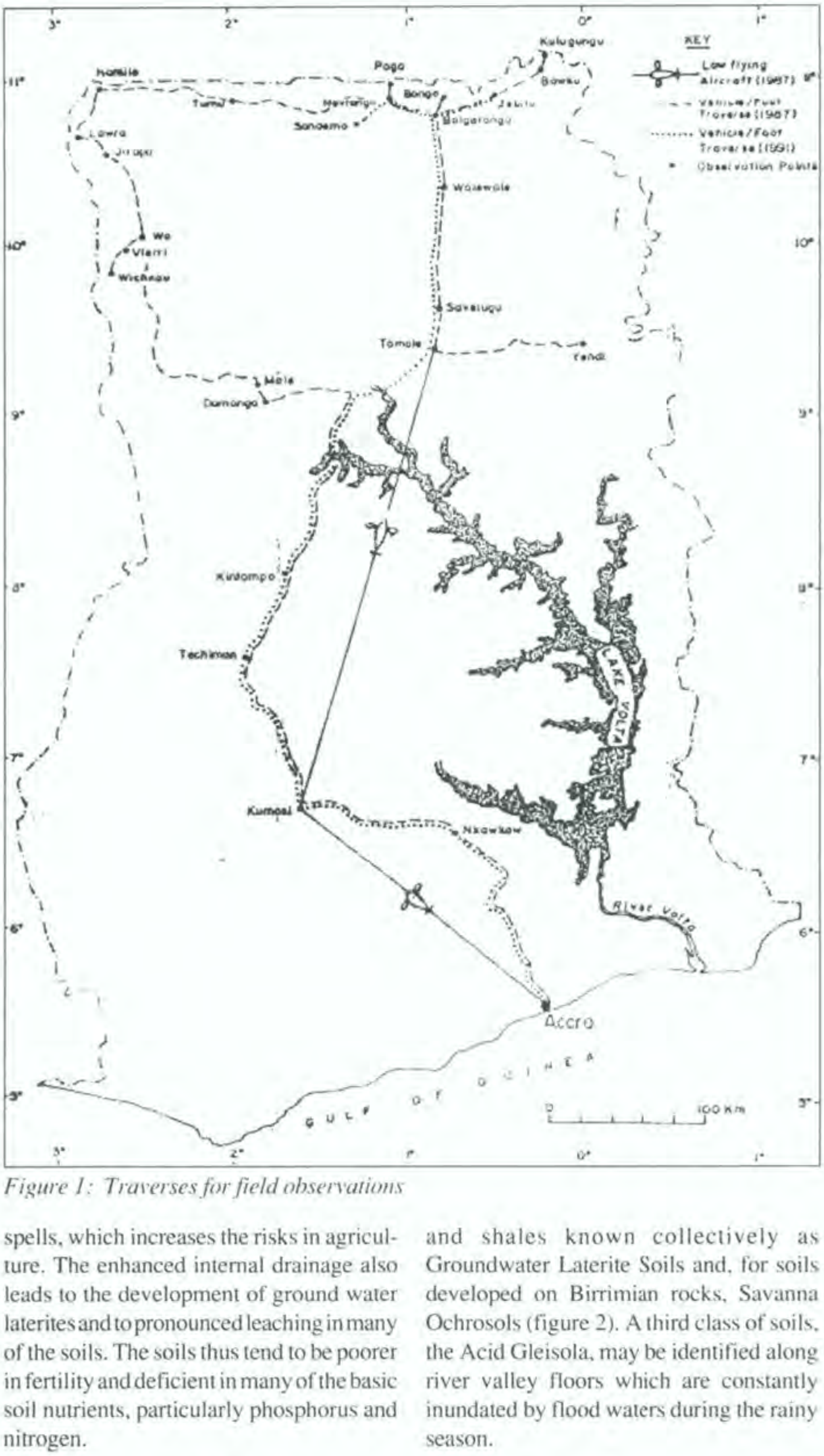


Figure 1: Traverses for field observations

Soil Groups in Northern Ghana

Two broad groups of soils may be identified in northern Ghana. These are soils developed over granitic rocks, sandstones and shales known collectively as Groundwater Laterite Soils and, for soils developed on Birrimian rocks, Savanna Ochrosols (figure 2). A third class of soils, the Acid Gleisola, may be identified along river valley floors which are constantly inundated by flood waters during the rainy season.

Desertification in Northern Ghana

Considerable differences in opinion exist among scientists with regard to the meaning of *desertification*. Indeed, at the Ad Hoc

Consultative Meeting on Desertification held by UNEP/DC-PAC in Nairobi, Kenya, 15-17 February 1990, as many as thirteen different definitions of the term could be identified (Odingo, 1990, pp 71-72). In this paper, and following general consensus reached at the Consultative Meeting, *desertification* means land degradation resulting from the adverse impact of human activities in arid, semi-arid and dry sub-humid areas (Odingo, 1990; Kassas, 1974).

In other words, desertification is not the same as drought/desiccation; neither does it refer to the movement of desert sand-dunes or desert encroachment which occurs at the immediate margins of natural deserts. 'Desertification refers to the various processes of ecological degradation by which the biodiversity of land (in economic terms) is reduced' (Kassas, 1988). It is a gradual process and it operates through systems of landuse that overtax the inherent bio-productive capacity of land.

The most conspicuous feature of desertification includes the rapid reduction in the amount of vegetative cover (deforestation and overgrazing) and in the quality of vegetation (biodiversity). Thus, a previously wooded vegetation may be converted into degraded savanna (savannazation) and subsequently into grass land (grassification) and, finally, to bare ground (devegetation). But the substantive issue of definition is centred on the ability or otherwise of the land to regenerate itself, as it transforms itself into an unproductive and barren wasteland. Once the land has become bare, the soil becomes exposed to erosion, leaching, laterite formation and further degradation until it becomes a true man-made desert, which completes the desertification cycle.

The following points in the definition of desertification need to be emphasised by way of summary, namely:

1. Desertification simply means man-induced land degradation but only in the context of arid, semi-arid and dry sub-humid areas of the earth. Land degradation elsewhere (for example, in the high tropical rainforests) cannot be referred to as desertification.
2. The word *land* is used widely to include soil, water resources, land surface and vegetation or crops.
3. *Degradation* refers to the reduction of resource potential systematically over a long period of time by one or a combination of processes acting on the land. These processes of desertification include water erosion, soil leaching, wind erosion, sedimentation/silting, reduction in the amount of vegetation (deforestation), reduction in the quality of vegetation (biodiversity), hardening of the ground (compaction, declining soil fertility and formation of dust bowls, etc).
4. Time is another important component in the definition of desertification since it is a slow process which manifests itself after a long period of time.
5. Finally, there is the issue of reversibility and irreversibility of desertification. According to Kassas (*op cit*), desertification is reversible only in the initial stages. At the most advanced stages it may not be reversible as the land will probably have become a true wasteland. In this sense, desertification is only partially reversible.

It is this view of desertification - the transformation of previously productive land into unproductive wastelands or deserts through the activities of man in fragile ecological zones - which is at the basis of this article.

This process of land degradation has obviously been going on in northern Ghana since the turn of the century when the population began to increase. However, it was only after the infamous Sahelian drought (1968-1973) that the problem appeared to have come into the forefront of national concern in Ghana. Unfortunately, the problem came to be conceptualized in the context of 'marching sands and encroaching deserts' (Odingo, 1990). Subsequently, the Ghanaian public came to believe that their sub-humid areas in the north were becoming desertified as a result of the southward expansion of the Sahara Desert. Indeed, in public discussions, various estimates of the speed at which the Sahara was presumed to be moving down south towards Ghana were given, ranging between 5 and 11 km a year. This formulation of the desertification process, in effect, absolved Ghanians and shifted the blame for the increasing desertification of the soils in northern Ghana to the Sahara Desert. The reformulation of the problem of desertification which placed man at the centre of the issue thus called for field work

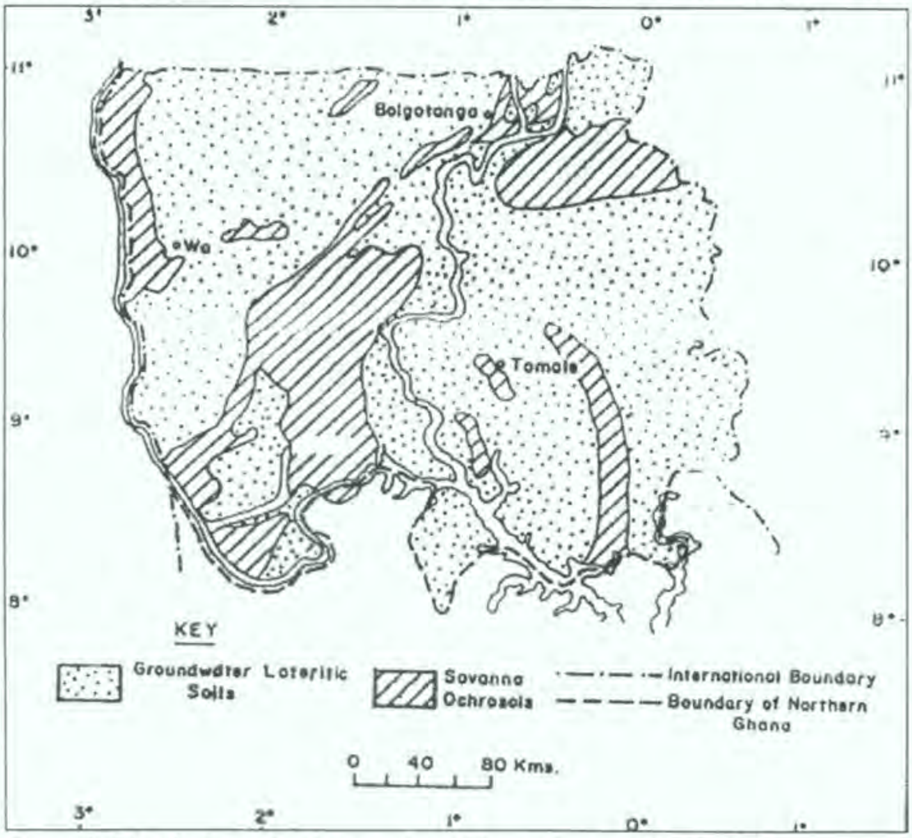


Figure 2: Distributions of soils in northern Ghana. Source: USAID, 1990.

to assess the extent to which man was contributing to the desertification process in northern Ghana.

Aims and Objectives

The main aim of this study was consequently to understand the desertification process in northern Ghana and the extent of damage that has already taken place in the area. This resolved readily into the following objectives, namely:

1. To identify the areas which are experiencing desertification of varying intensities in northern Ghana;
2. To identify the different forms of the desertification processes in northern Ghana; and
3. To identify the social, cultural and economic factors responsible for the increasing spread of desertification in northern Ghana.

Methods

Two scientists working with the Forestry Department of Regional Forestry Officers (RFO) in charge of the northern region and the Upper-East and Upper-West regions were requested to identify lands with visible signs of degradation, as well as the (community) afforestation projects in northern Ghana (mainly on degraded lands) for inspection by a 10-member team (including myself) from the Forestry Commission of Ghana.

The field observations were effected through vehicle and foot traverses, supplemented with informal aerial observation from a low-flying Ghana Airforce aircraft (figure 1). Opinion leaders of the area including priests, traditional rulers, high-ranking civil servants and peasants were also interviewed on the environmental changes and desertification taking place in the area.

At the end of each day's field observations the team discussed the extent and intensity of desertification with the two Regional Forestry Officers and other local experts (informed opinion) in a manner similar to Dregne's (1988) *Structured Informed Opinion Analysis*. Signs of desertification observed in the field were also compiled.

Available literature on the soils of northern Ghana was reviewed (Adu, 1969; Ramsey and Rose-Innes, 1963; SRI, 1973; Korem, 1985, etc) together with reviews on desertification (Odingo, 1990; Kassas, 1974, etc).

A second field trip in 1991 offered an opportunity to cross-check the validity of the basic conclusions made from the earlier observations. This second survey was organised by the Department of Geography and Resource Development, University of Ghana, Legon, for the Environmental Protection Council, Accra, Ghana. This paper is derived from notes made during that second field trip. The follow-up-study was also based on vehicle and foot traverses but limited in coverage to the Upper-East Region for in depth observation of the social, economic and cultural factors related to the desertification process.

It also utilized a 1989 satellite subimage (SPOT) for detailed study in the Bongo and Zebilla areas. Places that had registered signals as completely bare were located and visited for ground-truthing. Local farmers, scientists, chiefs, etc, in the area were again interviewed on their informed opinion on the current processes of land degradation occurring in the study area.

Observations

General Evidence of Desertification

The following signs of desertification were observed:

1. Acute shortage of firewood (deforestation);
2. Shortage of wood (poles and twigs) for building houses;
3. Large areas of completely bare ground and fields with boulders;
4. Farmlands rendered visibly barren and abandoned;
5. Several hectares of compacted lateritic grounds.
6. Eroded landscapes (rills, sheet erosion and gullies);
7. Silted rivers and reservoirs (dams);
8. Eroded hills with exposed boulders on hillsides (for example, on the Tongo Hills on the approach from Bolgatanga).

Areas Affected by Desertification

The threat of desertification was observed to affect nearly two-thirds of the study area in varying intensities (figure 3). Examples of places that were considered to be visibly desertified include the Bawku-West and Bawku-East district north of Bolgatanga (Upper-East Region); the 'Badlands' of western Dagomba around Tamale (Northern Region); and the Hamile-Lawra-Jirapa-Vierri axis (Upper-West Region).

The territory crossed by the major trunk roads also showed moderate signs of desertification. However, the thinly populated territory between Tumu and Damongo did not show any signs of desertification.

Physical Characteristics of Soils of Desertified Lands

The desertified soils had the following physical characteristics. They were sandy, gravelly to stony, shallow, lateritic, heavily eroded and devastated by rills and gullies in places. The principal form of soil erosion was sheet erosion.

Causes of Desertification

Deforestation

It was observed that deforestation was the most important cause of land degradation and desertification in northern Ghana.

The increased population pressure in the area as a whole and the corresponding increase in agricultural expansion, specifically in cultivation, are the main causes of deforestation. Thus, the highest population density areas were found to be more desertified, which included all the desertified areas identified above. It follows then that the best way for 'arresting' desertification in northern Ghana is to grow back the forest through massive afforestation programmes and improve cultivation practices. Unfortunately, there is much superstition against the planting of trees among many of the ethnic groups in northern Ghana. As the proverb goes: *If you plant a mango tree you will never live to eat the fruit which the mango tree you planted bears.*

Other constraints to community afforestation programmes have been discussed by Adam Abu (1989). To overcome these problems the suggestion has been made for the establishment of an Afforestation Commission to coordinate afforestation efforts in Ghana.

Factors of the Physical Environment

As already observed, the dry sub-humid climate does not provide adequate moisture

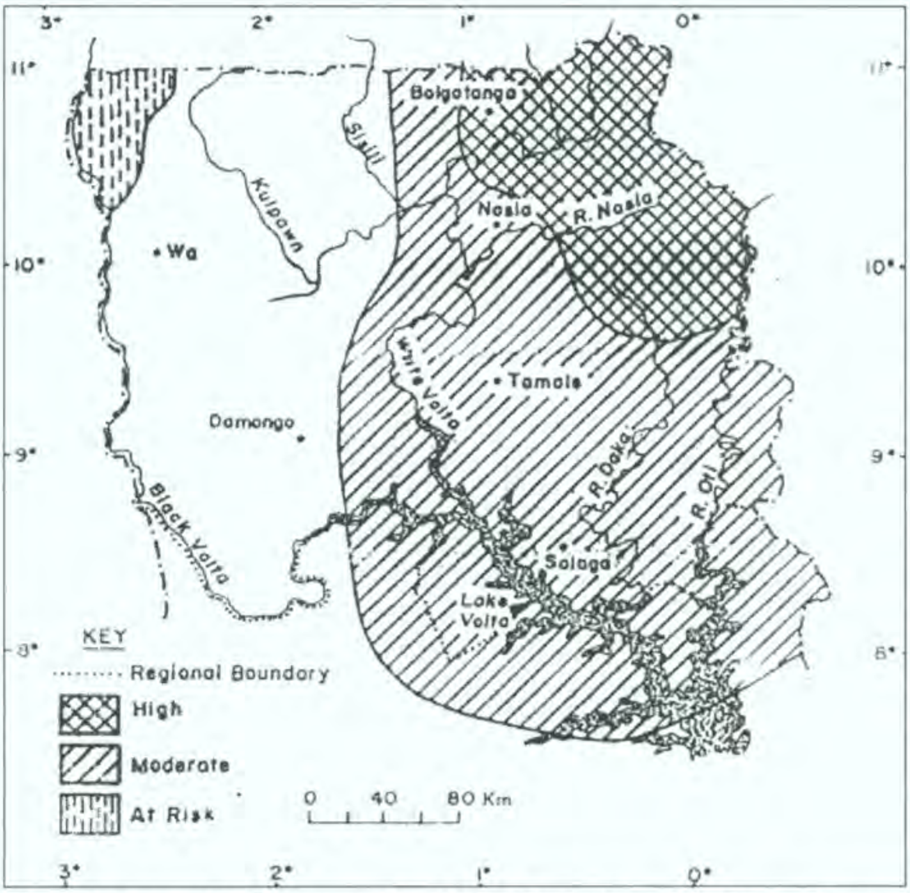


Figure 3: A generalized representation of desertification hazards in Ghana. Source: UNSO (1986).

for effective disintegration of parent material into the soil. As a result, there is a dominance of fragile sandy soils which are susceptible to erosion and leaching. Thus, the soils are readily exhausted and turned into degraded landscapes.

Socio-Cultural Factors

Four general aspects of culture which were considered to contribute in some measure to desertification in northern Ghana, in addition to the general attitude towards tree planting, include the following:

1. Bad landuse (cultivation) practices;
2. Animal husbandry practices (overgrazing);
3. The use of crop residue for fuel;
4. Road rehabilitation damage to arable lands.

Bad Landuse Practices (Cultivation)

The use of the hoe, bullock ploughs and tractors destroy the fragile structure of the soils. This makes the finer particles of the soil easy to wash or blow away, leaving the coarse-textured particles, gravels, stones and boulders behind. Similarly, ploughing along the slope of land also increases erosion. The general use of fire as an agricultural tool also has the effect of reducing the humus content of soils which promotes soil erosion and general degradation of the land (A. Korem, 1985).

Overgrazing

It was also observed that the large livestock numbers also contribute significantly to the desertification of soils by helping to lay bare soils (overgrazing).

Use of Crop Residue for Fuel

It has already been explained how crop residues such as corn and millet stalks are carried away from the field for use as fuel after harvest. This practice probably contributes to the low humus content of the soils and renders the soils increasingly impoverished over time.

Road Rehabilitation

The effect of road re-graveling, re-shaping and general rehabilitation on land degradation and desertification has not yet been mentioned in available literature. The fact nonetheless remains that most of the roads in northern Ghana are dirt roads which are washed away every year with the onset of the rains and repaired every year when the rains subside. The (fertile) topsoil of the land are mechanically removed in order to reach the gravel layer which is mined for the annual road rehabilitation programme. These topsoils are never returned but heaped in mountains and left to be washed away by the next rains. The result is that the affected lands, deprived of their rich topsoils, have been artificially rendered fragile and prone to desertification. Thus, the areas crossed by the network of roads in the study area were showing considerable signs of degradation and severe to moderate desertification hazards (figure 4 / page 48).

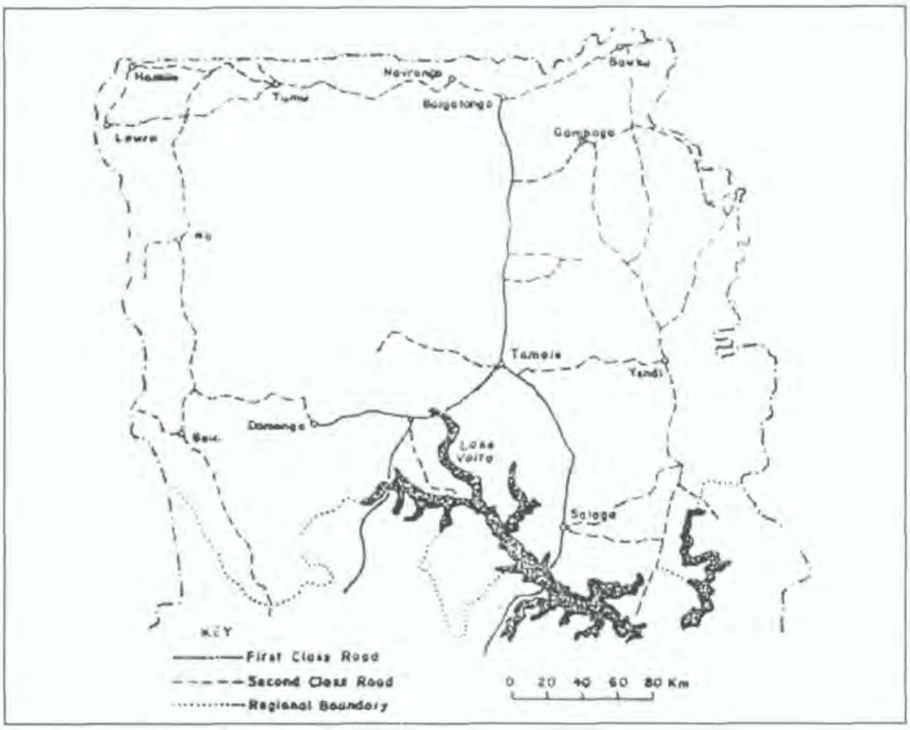
Conclusion

It is a fact that a significant proportion of northern Ghana is threatened by desertification. To contain the situation and restore the areas's ecological balance, the following policy measures are recommended:

1. Afforestation: There is the need to institute an effective afforestation programme to plant back the vegetation, as already discussed. In this sense, the idea of setting up the proposed Afforestation Commission to coordinate the effort needs consideration.
2. Cooking Stoves (Domestic Energy Requirements): The government of Ghana is already implementing a policy to provide gas cookers, improved fuel-saving coal pots and other cooking stoves to meet the domestic energy needs of the people at subsidized prices. The net effect of this policy is to reduce the pressure on the vegetation for fuelwood. The government of Ghana is also extending electricity to rural areas in a rural electrifica-

tion programme. Both policies must be accelerated to reach more of the areas in northern Ghana threatened with desertification.

3. Landuse Practices: Public education on the correct way to plough, apply chemical fertilisers and use new farming methods, such as alley farming, must be intensified in northern Ghana to reduce the threats of desertification.
4. Resettlement Schemes: There are plans to resettle farmers from the overcrowded districts to the thinly populated areas such as the Fumbisi Valley to relieve the pressure on the land in the overcrowded areas. Similar resettlement schemes have failed in the past due to cultural reasons. There is, therefore, the need for research to avoid past mistakes in this direction.
5. Permanent Surfacing of Rural Roads: The fact that poverty is the greatest cause of environmental degradation is clearly illustrated by the problems created by the annual re-graveling of roads in the area (for a discussion of the relationship between poverty and environmental degradation see Benneh, G, 1990, *Towards Sustainable Development: An African Perspective*, Geografick Tideskrift, vol. 90, pp2). In this connection, there may be the need to tar the roads with bitumen to convert them into permanent roads to stop the annual large-scale removal of top soils, which destroys the land and makes it prone to desertification. In the meantime, there may be the need for a national policy requiring road contractors to return top soils on the land rather than allowing these to stand in heaps only to be washed away into streams.
6. Inter-Disciplinary Research on Desertification: Although soil analysis may rightly 'belong' to soil science, it is doubtful if soil degradation (desertification) research is really a field for study by soil scientists alone. As this paper has demonstrated, desertification is largely a cultural phenomenon. The increasing spread of desertification in northern Ghana (and elsewhere) must thus offer the opportunity for the cross-fertilization of ideas between soil scientists, geographers and other social scientists on the cultural dimensions of soil degradation and desertification. Such collaborative efforts should lead to measurement of the components of desertification in northern Ghana.



Road network in northern Ghana.

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Acknowledgement

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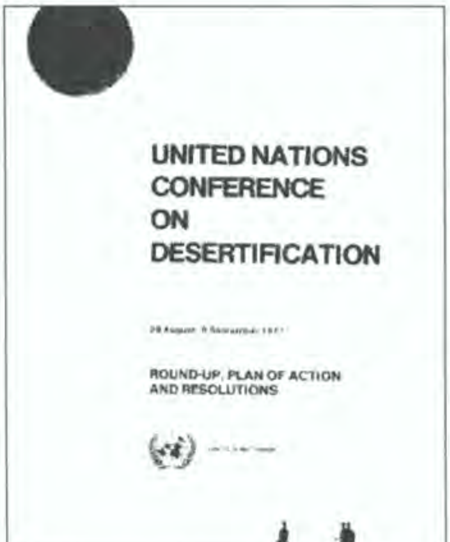
UNEP Governing Council Decision 17/14 - Desertification

1. Implementation of the Plan of Action to Combat Desertification 1991-1992



The Governing Council,

Recalling General Assembly resolutions 32/169 and 32/172 of 19 December 1977, 33/89 of 15 December 1978, 34/184 of 18 December 1979, 35/73 of 5 December 1980, 36/190 of 17 December 1981, 37/147 of 17 December 1982, 37/218 of 20 December 1982, 38/160 of 9 December 1983, 39/168 A of 17 December 1984, 40/198 A of 17 December 1985, S-13/2 of 1 June 1986, 42/189 A of 11 December 1987, 44/172 of 19 December 1989, 45/212 of 21 December 1990, 46/161 of 19 December 1991, 47/190 and 47/191 of 22 December 1992,

Recalling in particular General Assembly resolution 47/188 of 22 December 1992 by which the General Assembly decided to establish an Intergovernmental Negotiating Committee for the elaboration of an international convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa, and without prejudging the potential impact of the results of the Intergovernmental Negotiating Committee on the United Nations Environment Programmes's programme in the field of combating desertification,

Recalling also its decisions 9/22 A and B of 26 May 1981, section VII of its decision 10/14 of 31 May 1982, section VII of its decision 11/7 of 24 May 1983, and its decisions 12/10 of 28 May 1984, 14/15 A of 18 June 1987, 15/23 A of 25 May 1989, 16/22 A of 31 May 1991 and its decision SS.III/1 of 5 February 1992,

Considering the report of the Executive Director on the implementation in 1991-1992 of the Plan of Action to Combat Desertification (UNEP/GC.17/14),

Also considering those parts of the 1991 (UNEP/GC.17/11) and 1992 (UNEP/GC.17/12) reports of the Administrative Committee on Coordination dealing with the coordination and follow-up of the implementation of the Plan of Action to Combat Desertification,

Aware of chapter 12 ("Managing fragile ecosystems: combating desertification and drought", and 38 ("international institutional arrangements" of Agenda 21, as endorsed by the General Assembly,

Reaffirming its conviction that the Plan of Action to Combat Desertification is one appropriate instrument to assist Governments in developing national programmes for arresting the process of desertification, and that it has contributed essential elements to chapter 12 of Agenda 21,

1. *Takes note* of the report of the Executive Director on the implementation of the Plan of Action to Combat Desertification in 1991 and 1992, and of the compatibility of the action taken with the recommendations of chapter 12 of Agenda 21;
2. *Authorizes* the Executive Director to submit the report, on behalf of the Governing Council, through the Economic and Social Council, to the General Assembly at its forty-eighth session;
3. *Encourages* the ongoing efforts by the United Nations Environment Programme to define appropriate methodologies for monitoring and assessment of desertification, to carry out mapping of thematic indicators of desertification and to assign benchmarks and progress indicators for desertification control, along with other indicators of global changes within the system-wide Earthwatch programme;
4. *Requests* the Programme to provide the information gathered as a result of the efforts referred to in paragraph 3 of the present decision to the Governments of the countries from which it has been collected;
5. *Encourages* the United Nations Environment Programme to con-

tinue to compile, disseminate and catalyze the further development of successful desertification control project designs and implementation methodologies, including model land-use and socio-economic development programmes for marginal drylands and use of food aid in drought relief and refugee rehabilitation programmes;

6. *Requests* the Executive Director to continue to promote international cooperation and to intensify and expand, within the existing resources, the United Nations Environment Programme's regional/subregional joint ventures for implementation of a coordinated Plan of Action to Combat Desertification, as recommended in chapter 12 of Agenda 21, especially in regional/national capacity building, training, research, methodology and technology development and dissemination, as well as in formulation and implementation of national plans of action to combat desertification;
7. *Calls upon* all the other United Nations agencies and organizations concerned to reinforce their involvement in the implementation of the Plan of Action to Combat Desertification;
8. *Requests* the Executive Director to continue to cooperate fully, within existing resources, in the preparations for the desertification convention by the International Negotiating Committee, *inter alia*, by making available the scientific and technical resources of the secretariat.

2. Financing and Other Measures in Support of the Plan of Action to Combat Desertification

The Governing Council,

Recalling General Assembly resolutions 34/184 of 18 December 1979, 36/191 of 17 December 1981, 37/220 of 20 December 1989, 42/189 C of 11 December 1987, 44/172 A of 19 December 1989 and 46/161 of 19 December 1991,

Recalling also its decisions 13/30 A of 23 May 1985, 14/15 D of 18 June 1987, 15/23 B of 25 May 1989 and 16/22 B of 31 May 1991,

Noting the discontinuation of the global financing mechanisms of the Plan of Action to Combat Desertification, namely, the Special Account and the Consultative Group on Desertification,

1. *Takes note* of the decision by the participants in the Global Environment Facility, in the ongoing process of restructuring the Facility, that activities on land degradation, in so far as they relate to the programme areas of the Facility, are eligible for funding from it;
2. *Requests* the Executive Director to intensify the United Nations Environment Programme interaction with the United Nations Development Programme and the World Bank on this issue;
3. *Invites* other international financing institutions and Governments to actively support practical measures aimed at implementing the Plan of Action to Combat Desertification and the provisions in chapter 12 of Agenda 21;
4. *Invites also* the regional financial institutions to actively support practical measures aimed at implementing the Plan of Action to Combat Desertification and the provisions in chapter 12 of Agenda 21.

3. Implementation in the Sudano-Sahelian Region of the Plan of Action to Combat Desertification

The Governing Council,

Recalling General Assembly resolutions 32/170 of 19 December 1977, 33/88 of 15 December 1978, 34/187 of 18 December 1979, 35/72 of 5 December 1980, 36/190 of 17 December 1981, 37/216 of 20 December 1982, 38/164 of 19 December 1983, 39/168 B and 39/206 of 17 December 1984, 40/198 B of 17 December 1985, S-13/2 of 1 June 1986 and 42/189 B of 11 December 1987, 44/172 B of 19 December 1989 and 46/161 of 19 December 1991,

Recalling also its decisions 13/30 B of 23 May 1985, 14/15 B of 18 June 1987, 15/23 B of May 1989 and 16/22 C of 31 May 1991,

Having considered the report of the Executive Director on the implementation of the Plan of Action to Combat Desertification in 1991-1992 and, in particular, the section on the implementation of this Plan in the Sudano-Sahelian region (UNEP/GC.17/14, section 5),

1. *Takes note* of the steps the United Nations Sudano-Sahelian Office has taken, on behalf of the United Nations Environment Programme, to implement the Plan of Action to Combat Desertification in the twenty-two countries of the Sudano-Sahelian region;
2. *Authorizes* the Executive Director to continue supporting the United Nations Sudano-Sahelian Office as a joint venture with the United Nations Development Programme, at least until the conclusions of the Intergovernmental Negotiating Committee for the development of a desertification convention become clear;
3. *Also authorizes* the Executive Director to request the United Nations Sudano-Sahelian Office to continue its activities at the national and local level to assist Governments in the region in developing and implementing national plans of action to combat desertification and to coordinate with other agencies involved in development and implementation of national strategies for sustainable development;
4. *Requests* the Executive Director, in consultation with the Administrator of the United Nations Development Programme, to amend the terms of reference (the Memorandum of Understanding) of the joint undertaking of the United Nations Environment Programme and the United Nations Development Programme to allow the United Nations Sudano-Sahelian Office to intensify its involvement in the desertification control efforts in the countries in the region with its subregional interface organisations;
5. *Also requests* the Executive Director in consultation with the Administrator of the United Nations Development Programme, in response to chapter 38 of Agenda 21 and

subject to the outcome of the Intergovernmental Negotiating Committee for the development of a desertification convention, to consider strengthening their efforts to establish joint support mechanisms for the implementation of chapter 12 of Agenda 21 in other regions/subregions affected by desertification, capitalizing on the United Nations Development Programme/United Nations Environment Programme/World Bank tripartite experience of the Global Environment Facility and fully coordinating their efforts with the United Nations regional commissions and other intergovernmental bodies on development and financing in the regions concerned;

6. *Invites* the United Nations Sudano-Sahelian Office to intensify its efforts to mobilize resources for continued assistance to its mandated countries combating desertification.

Implementation of the Plan of Action to Combat Desertification 1991-1992

A. Technical Assistance to Governments

1. National Plans of Action to Combat Desertification

1. The UNEP Governing Council, in its decision 16/22 A of 21 May 1991, requested the Executive Director to assist, within available financial resources, countries prone to desertification, at their request, in developing programmes for combating desertification within their development plans. As a consequence, UNEP continued to assist member Governments in developing their national plans of action to combat desertification (NPACDs). In a joint undertaking with the Economic and Social Commission for Western Asia (ESCWA) and the Food and Agriculture Organization of the UN (FAO), UNEP assisted the Governments of Bahrain, Oman, the United Arab Emirates and Yemen in the preparation of their NPACDs. Due to the Iraq/Kuwait conflict and the relocation of ESCWA, some of the activities had to be postponed from the original period of 1990-1991 to 1992-1993.

2. UNEP assistance to the Governments of Argentina, Mongolia and Peru on which the Executive Director reported to the Council at its sixteenth session (UNEP/GC.16/16), continued in 1991-1992. The first drafts of NPACDs have been developed for Peru, in cooperation with the National Office for Natural Resources Evaluation (ONERN), and for Argentina, in cooperation with the Instituto Argentino de Investigaciones de las Zonas Aridas (IADIZA). UNEP provided consultancy assistance to the Government of Mongolia to finalize the draft NPACD and three project documents for donors' consideration at the NPACD review workshop in 1993.

2. Pilot projects under the African Ministerial Conference on Environment (AMCEN) - Cairo Programme for African Cooperation

3. Throughout 1991-1992 UNEP, through its Desertification Control Programme Activity Centre (DCPAC), continued to provide assistance to the Governments of Mozambique and Zimbabwe for the formulation and initiation of pilot village projects. In Zimbabwe, the implementation of pilot projects is under way, with financing support from the Canadian International Development Agency (CIDA), and the UN Development Programme (UNDP). In Mozambique, the follow-up of the project was hampered by the political situation in the project area.

4. In support of the AMCEN pilot village programme UNEP, with the Institute of Environmental Science of Nanjing, China, in 1990 started the training of African villagers and technicians in ecological farming. In October 1992, a training workshop was organized in Nanjing for 20 French-speaking African farmers and technicians from 17 countries.

B. Regional Actions and Networks

5. The role of subregional organizations in the efficient implementation of the PACD has been underlined by the Administrative Committee on Coordination (ACC). Accordingly, UNEP provided assistance in 1991-1992 to subregional organizations such as the Southern African Development Coordination Conference (SADCC); the Conference of Arab Ministers Responsible for Environment (CAMRE); the African Deserts and Arid Lands Committee (ADALCO); the Desertification Control Research and Training Network for Asia and the Pacific (DESCONAP); and the Task Force of Sahelian Dryland NGOs (GONGSA).

A typical soil profile with extremely high gypsium accumulation at a shallow depth in an area affected by wind erosion in the Syrian steppe. UNEP/Arab Centre for the Study of Arid and Drylands Training Course: Wind Erosion in Dry Areas of the Arab World and its Control. *Photo: ACSAD, 1992.*

Southern African Development Coordination Conference (SADCC)

6. In response to the SADCC request to the members of the IAWGD in 1989, UNEP provided consultancies and training to support SADCC's formulation of the Plan of Action for the Kalahari-Namib Region (Integrated land-use planning, rangeland monitoring, protection and rehabilitation). During 1991-1992, UNEP supported the Environment and Land Management Sector Coordination Unit of SADCC to provide assistance to the Kalahari-Namib countries for elaborating and developing projects under the Plan.

Conference of Arab Ministers Responsible for Environment (CAMRE)

7. Through its Arab League Liaison Office in Cairo, UNEP has been assisting the Secretariat of CAMRE in initiating its priority environmental programmes, which include desertification control. CAMRE, in collaboration with UNEP and the Arab League Educational, Cultural and Scientific Organization (ALECSO), organized a subregional workshop for decision makers on the experiences and future orientations of the Green Belt Project of North Africa (GBPNA).

African Deserts and Arid Lands Committee (ADALCO)/African Ministerial Conference on the Environment (AMCEN)

8. UNEP's Desertification Control PAC continued to serve as the secretariat for the African Deserts and Arid Lands Committee (ADALCO) of AMCEN and serviced the fifth ADALCO meeting held in Harare in 1991. UNEP also assisted ADALCO through the provision of consultancies to carry out two subregional studies: strengthening of the Green Belt Project of North Africa; and development of the nubian sandstone aquifer.

Desertification Control Research and Training Network for Asia and the Pacific (DESCONAP)

9. The regional network of research and training centres on desertification control in Asia and the Pacific that makes up DESCONAP was established by the Economic and Social Commission for Asia and the Pacific (ESCAP) in 1988, with financial support from UNDP and UNEP. The objective was to strengthen technical cooperation among the research and training institutions in the region by combating desertification through the development of appropriate expertise at the policy and programme-management levels and through the identification of investment projects. Eighteen Governments of the region (Afghanistan, Australia, Bangladesh, China, India, Indonesia, Iran, Japan, Mon-

golia, Nepal, Pakistan, Philippines, Thailand, Viet Nam and four CIS countries), three UN Organizations (UNDP), the UN Educational, Scientific and Cultural Organization (UNESCO), and the World Meteorological Organization (WMO), the South Asia Cooperative Environment Programme (SACEP) and a number of NGOs, including the International Council of Women (ICW) have joined the network and designated their official focal points.

10. Considering the extent of the problem of desertification and its impact on the land resources and population of the region, UNDP and UNEP have given high priority to DESCONAP.

11. The third Regional Consultative Meeting and Tripartite Review Meeting of the DESCONAP project was held in Thailand in February 1992, to consider its second phase and the 1992-1993 activities of its Action Plan on Desertification Control in Asia and the Pacific to the Year 2000.

12. During the period under review, the emphasis of the work programme was on activities related to desertification assessment; promotion of training and research on desertification control; technical cooperation among network members; and involvement of NGOs and women's groups.

13. Within the framework of DESCONAP, four regional seminars and workshops on issues related to desertification control were organized by ESCAP, in cooperation with UNEP and regional training and research institutions. With the aim of developing a unified methodological approach for desertification assessment and mapping, in November 1992 ESCAP, in cooperation with UNEP, organized an expert group meeting in Tehran for the Asia-Pacific and West Asia regions, hosted by the Government of Iran.

Task Force of Sahelian Dryland NGOs (GONGSA)

14. In cooperation with the International Institute for Environment and Development (IIED) UNEP supported the development and strengthening of the subregional 'Survival in the Drylands' information network in the Sahelian countries by providing training for 35 people in participatory appraisal methods; holding two regional meetings of the Task Force of Sahelian Dryland NGOs (GONGSA); publishing eight *Haramata* newsletters and 16 issue papers; and producing 18 desertification maps and two wall charts.

15. In addition to improving the dissemination of relevant scientific and development information on desertification over the English- and French-speaking areas of Western Africa, UNEP provided support in the preparation of the declaration of the specific concerns of the Sahelian NGO's for the UN Conference on Environment and Development (UNCED) as well as support for their inputs into the preparation of the World Atlas of Desertification.

C. Training

16. UNEP, in cooperation with Governments and regional training and research institutions, continued to conduct training programmes in combating desertification; to enhance the technical capabilities of desertification-prone countries in tackling desertification and promote awareness of the threat. During 1991-1992, UNEP, in cooperation with ESCAP, the Arab Centre for the Study of Arid Zones and Drylands (ACSAD), IADIZA, UNEPCOM, the Green Belt Project of North Africa, ALECSO and the Governments of Argentina, China, Egypt, Mongolia and the Syrian Arab Republic organized training courses, workshops and seminars.

17. A total of 231 participants from Africa, Asia and Latin America were trained in the management of dryland natural resources, sustainable food production, monitoring and assessment of desertification, increased application of new technologies and public information. In keeping with UNEP policy, most of the training for developing countries was organized within the regions concerned: in Argentina, China, Egypt, Mongolia, the Syrian Arab Republic and Tunisia. In addition, IAWGD members, namely, the UN Sudano-Sahelian Office (UNSO), WMO, ESCAP and the International Institute for Environment and Development (IIED) organized training courses related to desertification control for a total of 4,900 participants from developing countries affected by desertification.

D. Assessment and Mapping

18. In accordance with General Assembly resolutions 39/168 of 17 December 1989, and 44/172 of 19 December 1989, and encouraged by Governing Council decision 16/22, the Desertification Control PAC, in close cooperation with the Global Resource Information Database (GRID) Programme Activity Centres of UNEP, and drawing on the data available at the University of East Anglia, United Kingdom (climate); the International Centre for Arid and Semi-arid Lands Studies of the Texas Technical University, United States (land statistics); and the International Soil Reference and Information Centre, Netherlands (soil degradation), completed four major undertakings during the period under review. The work was part of UNEP's general contribution to the UNCED preparatory process and provided inputs for Agenda 21, Chapter 12: 'Managing Fragile Ecosystems: Combating Desertification and Drought'.

19. The assessments covered the following areas:

- (a) Refinement and operationalization of the definition of desertification, for the purpose of assessment and mapping;
- (b) Refinement and quantification of the concept of world's drylands, for the purpose of desertification assessment;
- (c) Assessment of the global status of desertification, showing its occurrence in the world's drylands:
  - (i) By types of drylands (hyper-arid, arid, semi-arid, and dry sub-humid);
  - (ii) By continent;
  - (iii) By major types of land use (irrigated croplands, rainfed croplands, and rangelands); and
  - (iv) By degree of land degradation (slight-to-none, moderate, severe, and very severe).

20. The outputs of the above three assignments were reviewed by members of DESCON, IAWGD and several expert panels, and were submitted, through the Governing Council at its third special session (see UNEP/GCSS.III/3), to the fourth session of the UNCED Preparatory Committee.

21. The fourth major undertaking entailed assistance in the preparation and publication (by Edward Arnold Publishers, London) of the *World Atlas of Desertification*, containing maps of thematic indicators of desertification. The Atlas was made available to Governments at UNCED.

22. The Governing Council, in its decision 16/22 D, underlined the need to further

refine the definition of the concept of desertification, taking into account recent findings about the influence of climate fluctuations and the resilience of soils. In the report of the Executive Director to the Governing Council at its third special session 'Status of Desertification and Implementation of the UN Plan of Action to Combat Desertification' (UNEP/GCSS.III/3) desertification is defined as 'land degradation in arid, semi-arid and dry sub-humid areas (drylands) resulting mainly from adverse human impact. It is a widespread but discrete process of land degradation in space throughout the drylands, which differs significantly from the phenomenon of observed cyclic oscillations of vegetation productivity at desert fringes ('desert expansion or contraction') revealed by satellite data and related to climate fluctuations'.

23. To understand better the relationship between desertification and climate fluctuations, UNEP, with WMO and the International Biosphere Geosphere Programme/International Council of Scientific Unions and some national meteorological services, initiated a study on the interactions of desertification and climate. The first phase of the study, to be completed in 1993, has three major components: impact of climate change on desertification; impact of desertification on climate; impact of climatic variability, including drought, on desertification.

24. The issue of the resilience of soils is more complicated, as there are no recent findings except for a general notion by some geographers that soils of drylands have appeared more resilient than was previously described. However, this can only be proven once assessments can be based on a multitude of local direct measurements, rather than on global indirect estimates.

25. A UNEP-cosponsored International Symposium on Soil Resilience and Sustainable Land Use, held in Budapest from 28 September to

2 October 1992, brought together 164 scientists, representing 33 countries and 18 international organizations (including Commissions and Standing Committees of the International Society of Soil Science (ISSS)). The scientists concluded that soil science had no established definition for soil resilience and that the concept of soil resilience, particularly in terms of measurable parameters, was not used by soil scientists. In addition, the concept was considered to be too vague at present to be of any practical use. The symposium recommended a study of soil resilience and its relevance to sustainability of land use, including agriculture. ISSS is to place the issue on its agenda of scientific research priorities. UNEP is also assisting in the organization of a symposium on soil resilience and soil management, to be held within the fifteenth International Congress of Soil Science in Mexico in 1994.

26. In accordance with Governing Council decision SS.III/1, paragraph 12 (a)(i), requesting UNEP to give strong emphasis to 'refining the assessment of desertification especially at the regional and national levels', UNEP is currently undertaking several activities. In cooperation with ESCAP, FAO and UNDP, UNEP is assisting in preparing a comprehensive report for the Secretary-General on combating aridity, soil erosion, salinity, waterlogging, desertification and the effects of drought in South Asia, as requested by ECOSOC in its resolution 1991/97. The report contains detailed and precise data on the status of desertification in the South Asia region, that encompasses eight countries with a total population of over one billion. It will be presented to the ECOSOC substantive session of 1993 and, as decided by ECOSOC in 1992, will be an input for the negotiations on the convention on drought and desertification.

27. UNEP initiated a project for the worldwide accumulation of data on successful desertification control projects on the local or national scale, with a view to disseminating the experience of reliable success stories for replication elsewhere under similar socio-economic and ecological conditions. The database will complement existing data on the extent of desertification in the world and assist in mobilizing the resources needed to combat desertification. In cooperation with UNDP and other UN agencies, support is provided for developing countries for national and regional capacity building in the area of desertification assessment on local, provincial and national scales. The aim is to establish national and regional facilities for use by the Governments concerned and for the permanent monitoring of desertification.

E. Monitoring

28. Governing Council decision SS.III/1, paragraph 12 (a) (ii) requests the Executive Director to give strong emphasis in the work programme to 'promoting the adoption and the monitoring and evaluation of the effectiveness of the policy guidelines and course of action presented in chapter III of the report of the Executive Director' (see UNEP/GCSS.III/3). Within the UN system there are at present three valid documents that address the global problem of desertification and that contain policy guidelines and courses of action:

(a) The Plan of Action to Combat Desertification adopted by the UN Conference on Desertification (UNCOD) in 1977 and endorsed by the General Assembly. The substance of the PACD is still valid as indicated in the approved findings and recommendations of the External Evaluation of it in 1990 as endorsed by the UNEP Governing Council in its decision GC.16/22 D of 31 May 1991;

(b) The Chapter III of the Executive Director's report to the third special session of the Governing Council (UNEP/GCSS.III/3) which was noted with appreciation by the Council in its decision SS.III/1, paragraph 12 (a) (iii) and which contains the revised recommendations of the PACD; and

(c) The Chapter 12 of Agenda 21. Agenda 21 was adopted by UNCED in June 1992 and endorsed by the General Assembly at its forty-seventh session.

29. The above three documents are similar in content with regard to concerning the policy guidelines and courses of action. At the national and regional levels, it is up to Governments to decide which of the documents would be most practical for use as guidelines. At the international and global levels Agenda 21, as the latest document, incorporating earlier recommendations, will be used as the programming guideline by UNEP and other agencies and organizations of the UN system, but useful details will also be drawn from the earlier documents.

30. The Council at its third special session further requested the assignment of benchmarks and indicators of progress. This is a long-term undertaking to be implemented together with other indicators of global change within the system-wide Earthwatch programme. At present, an in-

tensive world-wide discussion is taking place on the parameters to be monitored and the data to be collected with regard to both the physical changes taking place and the human dimensions. Several international initiatives relevant to the problem of desertification are being pursued globally and regionally, such as the database core project of the ICSU/IGBP, and the World Soil and Terrain Digital Database (SOTER) project of UNEP/FAO/International Soil Reference Information Centre.

31. UNEP's Desertification Control PAC is actively participating in the initiatives outlined above, besides developing its own methodologies, and has planned relevant activities for the next biennium. The major emphasis will be on establishing an international network of sites for monitoring and assessing ecological and socio-economic change. Sites will be identified in the dryland countries that participate in the network. Each site, or preferably a transect representing different ecological situations, will remain national property, but will be available for the activities of the network. The network will be an element of the global Earthwatch programme, with an international coordinating unit and databank. These plans will be appropriately adjusted, once an international convention on desertification and drought has been adopted.

F. Information and Database

32. In 1991-1992, UNEP continued to disseminate information on programme results and problems related to desertification control around the world. Issue 18, 19, 20 and 21 of the *Desertification Control Bulletin* were published and distributed, with 4,500 English copies per issue. The *World Atlas of Desertification* (800 copies), containing maps of thematic indicators of desertification in three sections - global, regional (for Africa), and national - with various case studies for different continents, has been published and was distributed to Governments at UNCED and to relevant professionals in all regions of the world. In accordance with Governing Council decision SS.III/1, paragraph 10, the report on the Status of Desertification and Implementation of the UN Plan of Action to Combat Desertification was published and submitted to the UNCED preparatory process. *The World Desertification Bibliography* has been updated and distributed to libraries, research institutions, UN Organizations and universities (800 copies). During the period under review, a total of 15,000 copies of the above publications and of other documents on desertification control were disseminated to interested parties around the world.

II. Inter-Agency Working Group on Desertification (IAWGD) and Coordination of the Implementation of the PACD Withing the UN System

33. The eighteenth regular meeting of IAWGD was convened in Geneva at the headquarters of the World Meteorological Organization (WMO) from 9 to 10 September 1991, immediately preceding the eighth session of the Consultative Group for Desertification Control (DESCON) to review the documentation prepared for the UNCED preparatory process. The following UN Organizations and agencies participated in the meeting: FAO, UNCED Secretariat, UNEP/UNESCO/UNSO/UNDP, UN University (UNU) and WMO.

34. The 19th regular meeting of IAWGD was held in Vienna from 14 to 15 September 1992. Eleven UN Organizations participated: UN Department of Economic and Social Development (DESD), ESCAP, ESCWA, FAO, Office of the UN Disaster Relief Coordinator (UNDRO), UNEP, UNESCO, UN Industrial Development Organization (UNIDO), UNSO, World Food Programme (WFP) and WMO; and three subregional organizations, Arab Centre for the Study of Arid Zones and Drylands (ACSAD), the Sahel and Sahara Observatory (OSS) and the Southern African Development Coordination Conference (SADCC). The group reviewed ten reports on the implementation of the PACD (by DESD, ESCAP, ESCWA, FAO, UNDRO, UNEP, UNESCO, WFP and World Health Organization) and preliminary plans by the UN system to implement Chapter 12 of Agenda 21.

35. The activities undertaken and the assistance to developing countries provided by the UN system for the implementation of the PACD include:

- Assistance to countries to develop strategies to combat desertification, provided by ESCAP, ESCWA, the Economic Commission of Africa (ECA), FAO, the International Fund for Agricultural Development (IFAD), UNDP, UNEP, UNSO, World Bank;
- Projects aiming at integrated land use development, implemented or supported by DESD, FAO, IFAD, UNDP, UNEP, UNESCO, UNSO, World Bank, WMO;
- Activities in the fields of drought preparedness, drought monitoring and/or drought relief, which are well established in the programmes of DESD, FAO, IFAD, UNDP, UNDRO, WFP, WHO, WMO;
- Research projects and technology development programmes, supported by DESD, FAO, IFAD, UNDP, UNESCO, UNEP, UNIDO, UNSO, World Bank;
- Activities related to assessment and monitoring of desertification, carried out by DESD, ESCAP, FAO, IFAD, UNDP, UNEP, UNSO, WMO;
- Support for relevant training courses, scientific seminars and workshops, provided by ESCAP, FAO, IFAD, UNDP, UNESCO, UNEP, UNSO, WFP, WMO;
- Activities to raise public awareness of dryland degradation, carried out by DESD, FAO, IFAD, Regional Economic Commissions, UNDP, UNEP, UNESCO, and UNSO.

36. The Working Group at its nineteenth regular meeting noted that Agenda 21, Chapter 12, with its six programme areas could appropriately be considered as the new framework for activities addressing desertification and drought-related problems. It also noted that Chapter 12 builds upon the PACD adopted by UNCOD in 1977. Accordingly, many agencies, while still in the process of consolidating their approaches to the implementation of Agenda 21, are re-orienting their existing activities to fit into the new framework and are focussing on new activities to fill any gaps.

37. The Group further recalled that a major constraint in implementing anti-desertification programmes was the lack of financial and other resources. In this regard, it was noted that the participants in the Global Environment Facility (GEF) had

agreed to consider anti-desertification projects for financing under the Facility, as long as they were related to the four adopted global priority areas of GEF. The Group considered it important to continue the efforts to establish desertification as a priority issue on its own merits within GEF. Several members of the Group pointed out that in disaster prevention and rehabilitation there was a trend towards increasing assistance for relief rather than for developmental activities and that there was a need to find ways in which relief work could also serve longer-term development.

38. The Group discussed the proposal contained in Agenda 21 that the General Assembly establish an intergovernmental negotiating committee for the elaboration of an international convention on desertification, and was of the opinion that such a convention would enhance national and international efforts to combat desertification.

III. The Consultative Group for Desertificaiton Control (DESCON)

39. The Governing Council, in its decision 16/22 A, paragraph 9, authorized the Executive Director to convene the eighth session of DESCON as a session of special character to review the draft report on the implementation of the PACD before the report was made available to the Preparatory Committee of UNCED and to invite all interested Governments, donor agencies and intergovernmental agencies to that session.

40. The eighth session of DESCON was convened at WMO headquarters, Geneva, from 11 to 12 September 1991 and was attended by 16 Governments (Australia, Botswana, Brazil, Chile, China, Denmark, Ethiopia, Finland, Germany, Japan, Kenya, Nigeria, Peru, Sweden, Switzerland and the United States), seven UN organizations (FAO, UNCED Secretariat, UNEP, UNESCO, UNSO/UNDP, UNU and WMO), the Italian non-governmental organization CSARE-SILVA, the Intergovernmental Authority on Drought and Development (IGADD), the Islamic Development Bank and 12 independent consultants invited by UNEP.

41. The Group reviewed the UNEP draft report on the status of desertification and implementation of the UN Plan of Action to Combat Desertification; the draft report of the Secretary-General on financial studies requested by the General Assembly in its resolution 44/172 on the PACD; and Chapter 6 of the state-of-the-environment report, on desertification and other kinds of land degradation. The comments and suggestions made by the Group were incorporated into the main documents before submission to the Governing Council at its third special session and, subsequently, to the fourth session of the Preparatory Committee of UNCED and to the Secretary-General of the UN.

IV. Financing and Other Measures in Support of the Plan of Action to Combat Desertification

Expert Studies

42. In its resolution 44/172 of 19 December 1989, the General Assembly requested the Secretary-General, with the assistance of the Executive Director of UNEP, to undertake studies on the financing of the PACD and other aspects of supporting it. The studies were carried out by UNEP and were reviewed by several expert panels, by the eighteenth IAWGD and DESCON-8 meetings and by the Governing Council at its third special session. Subsequently, the studies were made available to the UNCED Preparatory Committee at its fourth session with the aim of having them taken into account in the preparation of appropriate chapters of Agenda 21.

The Global Environment Facility (GEF)

43. On 30 April 1992, the participants in the GEF decided that land degradation issues, primarily desertification and deforestation as they related to the priority areas of the Facility, would be eligible for financing by the GEF. UNEP and UNDP organized an expert workshop in Nairobi from 28 to 30 October 1992, to discuss the main global issues raised by desertification/land degradation that have direct relevance to the established objectives of GEF, as presently defined and to discuss those issues that have global significance, but which do not presently lie within the framework of GEF. At the workshop, the 21 participating experts from all continents and representatives of FAO, UNDP, UNEP, UNSO, World Bank and WMO made recommendations for the GEF to consider at its meeting in Abidjan in December 1992. At that meeting, the participants in GEF reiterated the earlier decision of 30 April 1992, but did not reach consensus on including land degradation in the GEF as a priority area in its own right.

The Consultative Group for Desertification Control (DESCON)

44. In its decision 16/22 B, the Governing Council recommended: 'pending action by the General Assembly on the recommendations of the UN Conference on Environment and Development, the mandate of the Consultative Group for Desertification Control should be changed to concentrate on information exchange and coordination, reviewing the status of the Plan of Action to Combat Desertification and exchanging information on scientific research national programmes and the implementation of the Plan of Action to Combat Desertification and advising on further action against desertification'. In line with that decision, DESCON did not take any action towards financing of the PACD.

45. Further, in its decision 16/22 A the Governing Council invited 'donor Governments, intergovernmental bodies, including aid agencies and non-governmental organizations, to accord high priority in their bilateral and multilateral assistance activities to national programmes for combating desertification and for the rehabilitation of degraded land resources and to take into account the promotion of long-term ecological and social rehabilitation programmes in areas prone to desertification'. In its decision 16/22 B, the Council invited 'the international community to create the necessary economic and financial conditions that would enable countries prone to desertification to appropriate part of their resources to combat desertification'. Despite the urgent need for action in this field, no country or agency has reported any tangible progress in according high priority to programmes for combating desertification and rehabilitating degraded land.

UNSO

United Nations Sudano-Sahelian Office

UNSO-UNDP-UNEP joint venture to assist 22 countries in the Sudano-Sahelian region in anti-desertification activities (1991-1992)

Introduction

46. During 1991 and 1992, UNSO maintained a strong programme of assistance to the countries of the Sudano-Sahelian region, aimed at securing sustainable economic and human development, and focused on three major themes: the strengthening or creation of national capacities in planning and coordination for the improved management of natural resources; operational field activities; and public information and awareness-building activities. These were all supported and combined with resource mobilization. In addition, in accordance with General Assembly resolution 44/172 B of 19 December 1989 and Governing Council decision 16/22 C of 31 May 1991, an integral part of UNSO's work programme in 1991 and 1992 comprised assistance to the Sudano-Sahelian countries in preparation for UNCED.

A. Planning, Coordination and Monitoring

47. During the period under review, UNSO further strengthened its programme of assistance in planning, coordinating and monitoring the sustainable use of productive resources. The strategic framework process involves either the strengthening or the setting up of an institutional or inter-ministerial mechanism to coordinate the preparation of a national management strategy for natural resources and the implementation of the programme. UNSO currently supports the strategic framework process in 17 Sudano-Sahelian countries, with activities at various levels of implementation, depending on the country's specific situation. UNSO's financial support for those activities averages between $200,000 and $400,000 per activity, over a one- to two-year period.

48. Experience gained in assisting the Ecological Monitoring Centre in Senegal has resulted in the introduction of a more demand-driven approach to strengthening the national capacity, reinforcing the database and creating national networks for ecological monitoring, which are an important tool in environmental management. UNSO is currently initiating environmental information system (EIS) activities in Burkina Faso, Cape Verde, Gambia, Ghana, Ethiopia, Mali, Niger, Uganda and the United Republic of Tanzania. At the same time, with UNSO support, the Senegal Ecological Monitoring Centre is developing into an independent, self-financing institution, which also serves as a regional training centre.

49. UNSO continued the ongoing process of harmonizing the various natural-resource and environmental management programmes in the region. Further consultative meetings were organized at UNSO headquarters in April 1991 and November 1992, bringing together the organizations involved in such harmonizing work, namely, UNDP, UNEP, FAO, UNSO, the World Bank and the World Conservation Union (IUCN).

50. In light of the decisions of UNCED, UNSO is broadening existing strategic framework programmes in order to contribute to UNDP's new capacity-building initiative to develop and fund environmentally related capacity-building activities. This is an area in which UNSO has considerable expertise and should play a pioneer role.

51. In cooperation with UNDP, the World Bank and the African Development Bank, in 1992 UNSO launched a Joint Regional Programme Facility, which aims to strengthen national capacities to integrate the environmental dimension into all aspects of development planning. The facility will also establish a network of African experts and institutions, with the aim of fostering technical cooperation among African countries.

52. Other initiatives which have furthered regional information exchange include UNSO's cooperation with the Sahel and Sahara Observatory (OSS). An OSS/UNSO 'Survey of observation structures' was completed in 1992, which gives a comprehensive summary of the major activities in ecological monitoring.

B. Operational Field Activities

53. UNSO concentrates on projects and programmes geared towards integrated resource management and highlighting spe-

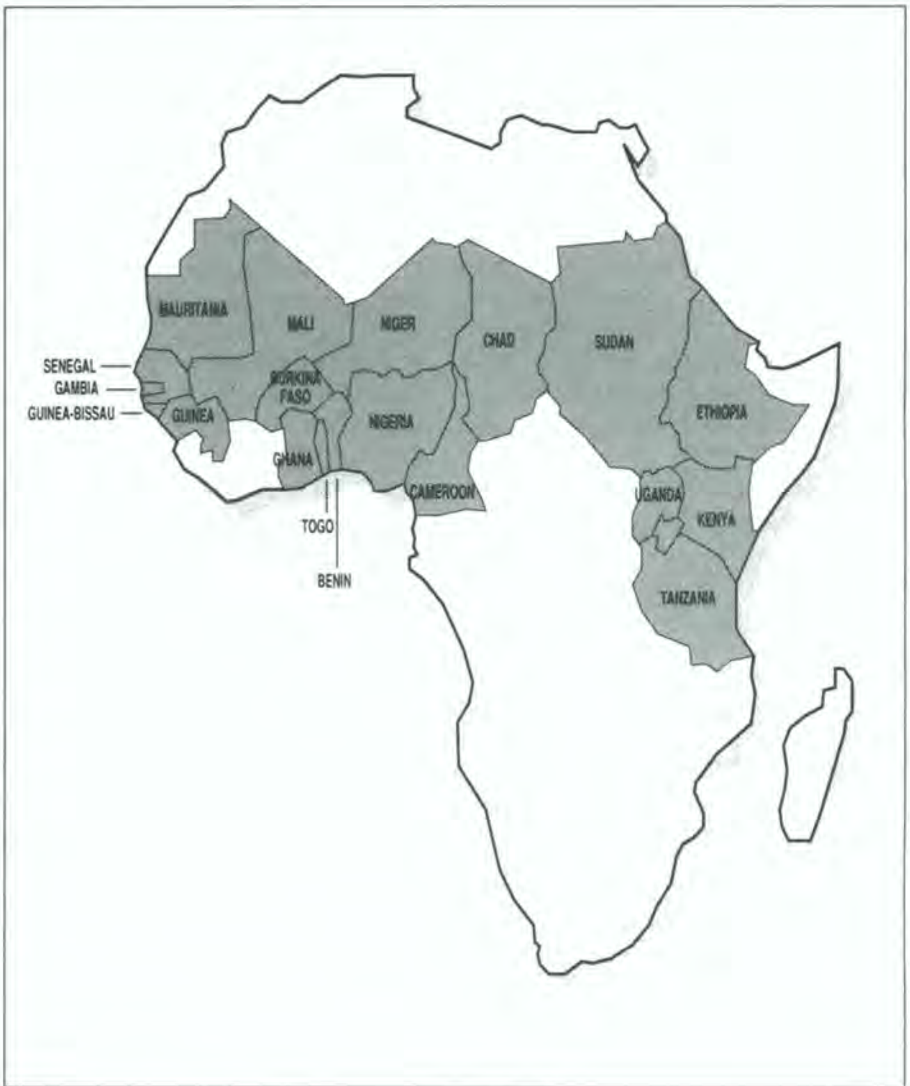
cific thematic areas - integrated village-based land management; pastoral development; and rangeland management. By incorporating past experience into innovative new approaches, relevant and replicable methodologies and techniques have been developed, which can be incorporated into plans for the sustainable development of natural resources and applied to other areas with similar ecological problems. This is very much in line with the thrust of Agenda 21 in relation to drought and desertification activities.

54. During 1991-1992, new field projects were approved for *inter alia*, agro-pastoral development in Chad and Kenya, land protection and desertification control in Sudan and Uganda, environmental education and awareness-building in Benin, and developing the national components of a regional land rehabilitation programme to provide tree seeds in Djibouti, Ethiopia, Sudan and Uganda. Subsequent phases of several existing projects were approved, for example assistance for green belt management around Niamey (Niger), together with various regional projects.

55. A new village-based land management project in Sudan, based around El Odaya in Kordofan, involves some 20,000 people in 66 villages. Focusing on desertification control, the project aims to establish self-reliant rural communities that develop and manage their own environment, supported by a revolving fund, 25 per cent of which will be devoted to activities proposed by women in the villages.

56. In Uganda, the Karamoja women's project is designed to promote socio-economic development and the environmental protection in Uganda's most arid, drought-prone region. The project includes an innovative pilot credit scheme for agricultural, agro-forestry and horticultural development. In addition, its approach encourages the participation of the community natural resource management, whereby the women design and implement the project.

57. Among ongoing programmes, the Sahel Programme, with a total budget of more than $25 million over five years, involves village land-based management in Burkina-Faso, Niger and Senegal. In partnership with the beneficiaries, the aim is to develop easily applicable management techniques for land development and natural resources, for use both nationally and in other similar areas, and to define and implement land management plans in cooperation with the participating villages.



UNSO countries.

58. Innovative projects for desertification control involving agricultural and rangeland management have been formulated for Benin, Eritrea, Kenya, Niger and Sudan.

59. Two new interregional projects emphasize the importance given to cooperation with non-governmental organizations. The first, implemented by the non-governmental organization SOS Sahel, is developing and refining participatory evaluation processes; the second, implemented by the International Institute for Environment and Development (IIED), is designed to provide a framework for dialogue and long-term cooperation between the research community and NGOs.

C. Information Activities

60. Information and awareness-building activities not only complement UNSO's work programme, but have various other functions. The publications prepared for UNCED on the status of drought and desertification and on alternative means of production serve to increase knowledge and awareness of drought and desertification in the Sudano-Sahelian region. The *Information Notes for UNCED* were published to assist delegations from the Sudano-Sahelian countries at the Preparatory Committee session in March 1992 and at the Conference itself. The *UNSO Report for 1990-1991* and a video production on UNSO activi-

ties were produced for a wide audience, to provide information and mobilize resources within the countries, the UN system and the donor community.

61. To disseminate the useful results of field experience, UNSO prepared two technical publications, the first dealing with reforestation in Ethiopia, and the second on sand encroachment control in Mauritania. UNSO also supported the making of a prize-winning and widely distributed film entitled 'Rivers of Sand', based on a successful project for the rehabilitation of Bourgou grass (*Echinochloa Stagnina*) areas in the inner delta of the Niger River, and short videos featuring UNSO projects: one on protecting the Road of Hope in Mauritania against sand encroachment (completed) and another on gum arabic rehabilitation in the Sudan (in preparation).

D. Resource Mobilization

62. The UNEP/UNDP joint venture to support UNSO in implementing the PACD in the Sudano-Sahelian region contributes the seed financing for project identification, formulation and monitoring, pilot projects, support to regional activities and organizations, information and awareness-building and training. In adopting its programme budget, the UNEP Governing Council, in recognition of UNSO's work and of the importance of the joint venture's support to UNSO's activities, approved the doubling of the programme support for 1991-1992.

63. Contributions to UNSO's general resources increased consistently, from $2.9 million in 1984 to $8.3 million in 1991. Earmarked funds also rose steadily. During 1991-1992, a total of 52 new projects were approved, with a value of $22,386,501. The support per project varies widely, from $3,000 for support-type projects, to about $7 million, reflecting UNSO's flexible approach in targeting different groups.

64. In 1992, however, financial support from donors declined considerably because of uncertainties about post-UNCED developments, restructuring within the UN system and the international economic situation. At the same time, a new momentum was created by UNCED, requiring additional funds to address the problems of the Sudano-Sahelian region and for the effective follow-up to Agenda 21. In the light of those considerations, UNSO has started a new round of consultations with traditional donors and has begun to investigate the possibilities of attracting new donors.

65. UNSO has also been looking into the potential for funding through other mechanisms, such as the GEF multilateral funds, regional and subregional development banks and the private sector, including charitable foundations and individuals. The participants in the GEF have agreed that land degradation (desertification and deforestation) projects would be eligible for GEF funding, provided they related to and were justified within one or more of the four priority areas of GEF.

66. UNDP/UNSO, UNEP and the World Bank organized a workshop in Nairobi in October 1992 for leading experts on land degradation, desertification and deforestation, with a view to establishing criteria for the land degradation projects eligible under the GEF and reviewing the global dimensions of the desertification problem in order to justify desertification as a GEF priority area in its own right. The findings of the workshop were presented to the meeting of GEF participants in December 1992. At that meeting, UNSO submitted two projects, prepared as part of the fourth GEF tranche, for final review and approval. Both projects, one in Benin and the other in Sudan, seek to combine anti-desertification efforts with schemes for carbon sequestration, using better village-based land-use systems to prevent the over-exploitation of marginal lands.

67. With regard to collaboration with the regional development banks, new initiatives include the joint regional programme facility mentioned in paragraph 51 above, supported by UNSO, UNDP, the World Bank and the African Development Bank. In order to tap into the resources available from corporations, trusts and individuals, UNSO supported the mobilization of resources related to the Drought Fund established by the Organization of African Unity.

E. UNCED Preparatory Process and its Follow-up UNCED Preparations

68. UNSO's aim during the preparatory process for UNCED was to assist the Sudano-Sahelian countries to take full advantage of the opportunity presented by the Conference to focus on the interdependence of environmental issues and development and to integrate environmental concerns into their development processes. It was particularly important to the Sudano-Sahelian countries to ensure that drought and desertification issues were placed high on the agenda of UNCED. To that end, UNSO assisted countries in defining their priorities by supporting the establishment of National Committees for UNCED and the preparation of national reports, by building awareness of the issues related to UNCED and by supporting the participation of countries in preparatory meetings and at the Conference itself.

69. Through the Joint Support Committee, (comprising UNSO, the Permanent Interstate Committee to Combat Drought in the Sahel (CILSS) and the Intergovernmental Authority on Drought and Development (IGADD)) UNSO organized two subregional meetings, one in Ouagadougou in February 1991 and the other in Cairo in July 1991, to facilitate a concerted approach to common subregional concerns. The outcome of those meetings: 'the Sudano-Sahelian Platform for Action on UNCED negotiations and beyond' contributed to the African Common Position for UNCED.

70. As a member of the Joint Secretariat (comprising UNDP, UNEP, ECA, OAU, the African Development Bank and the UNCED Secretariat), UNSO helped to organize and participated in the preparatory activities leading to the meeting of African Ministers of Planning and Environment, held in Abidjan in November 1991, which adopted the African Common Position.

71. As a participant in the UNCED preparatory committee working party on land and agriculture, UNSO cooperated closely with the UNCED Secretariat and other UN agencies and contributed sub-

stantially to the preparation of conference position papers on African issues and the elaboration of the programme areas on drought and desertification to be included in Chapter 12 of Agenda 21. In that context, UNSO produced two special detailed studies: an 'Assessment of desertification and drought in the Sudano-Sahelian region: 1985-1991', prepared in accordance with Governing Council decision 16/22 C, paragraph 3, to complement the UNEP report on the 'status of desertification and implementation of the PACD (UNEP/GCSS.III/3) and 'Alternative and sustainable systems of production and livelihood in marginal lands', investigating productive ways of generating income in stressed ecosystems, drawing on examples world-wide.

Agenda 21

72. UNCED drew attention - unprecedented since UNCOD in 1977 - to drought and desertification as problems of major concern affecting the global environment. The key environmental problems for countries in arid, semi-arid and sub-humid areas of Africa are drought and desertification and, as such, these were thus presented as priority areas for the conference agenda.

73. Chapter 12 of Agenda 21, containing the decisions of the conference on drought and desertification has now become the new frame of reference for anti-desertification measures, providing the guidelines for future action and the basis for evaluating current activities. It contains six programme areas which are concerned with the impact of desertification and drought and the underlying causes, mainly poverty. These major areas build on and embody the earlier PACD adopted by UNCOD in 1977, which UNSO is already mandated to implement, on behalf of UNEP, in the Sudano-Sahelian region.

74. UNSO's approach, integrating human development and natural resource management, and its ongoing activities accord well with Agenda 21. This approach and the experience gained over nearly 20 years in assisting dryland countries to combat drought and desertification strongly supports UNSO's role in implementing the anti-desertification measures outlined in Agenda 21.

UNCED follow-up

75. Agenda 21 gives guidelines for the future development of UNSO, with emphasis on strengthening the ongoing programme of assistance in planning and coordination and programme and project development, and in investigating new fields related to drought preparedness and alternative production systems.

76. As concerns the proposed convention on desertification, in line with the request contained in Chapter 12 of Agenda 21, the General Assembly in its resolution 47/188 of 22 December 1992 decided to establish an Intergovernmental Negotiating Committee for the elaboration of an international convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa, with a view to finalizing such a convention by June 1994. In the same resolution, the General Assembly invited UNSO to 'assist the countries covered under its mandate in their preparations and participation in the negotiating processes and to mobilize resources for this purpose'. In assisting the African countries in preparing negotiation process defining a joint understanding on the priority issues and objectives and, as far as possible, adopting a common position and approach, UNSO supported the consultative meeting organized by the OAU in Addis Ababa in October 1992.

77. To address those programme areas of Chapter 12 which have not yet been given special emphasis by UNSO, programmes are being drawn up for consolidated drought preparedness and drought relief, taking into account national planning framework processes. Attention is also being given to assisting alternative livelihood programmes for drought and desertification-prone areas, which will contribute to poverty alleviation and assist environmental refugees.

78. In its Chapter 38, paragraph 27, Agenda 21 calls for strengthening the role of UNSO, operating under the umbrella of UNDP and with the support of UNEP, so that UNSO can assume an appropriate major advisory role and participate effectively in the implementation of the provisions of Agenda 21 related to combating drought, desertification and land resource management. The experience gained by UNSO over the years could be used by all countries affected by drought and desertification, in particular those in Africa, with special attention to countries most affected or classified as least-developed countries.

79. Building on the existing close cooperation with the Permanent Interstate Committee for Drought Control in the Sahelian zone (CILSS) and IGADD, UNSO has made initial moves to create closer ties with other appropriate regional and subregional organizations, such as the Southern African Development Coordination Conference (SADCC) and the Maghreb Arab Union. Collaboration is also being strengthened with other regional partners, such as OAU, ECA and the African Development Bank, particularly in subregional consultations, joint strategic programmes related to the provisions of Chapter 12 of Agenda 21 and support for the negotiation process for the desertification convention.

80. For UNSO's initiatives to be successful, however, it is essential to secure substantial additional resources in order to step up its assistance programme, to maintain the momentum built up during UNCED and to implement the identified action programme.

UNEP/DC-PAC Training Programmes Organised by UNEP in Cooperation with Supporting Organisations (1993)

The overall aims of DC/PAC Training Programmes are:

- to facilitate the extensive use and application of proper anti-desertification techniques leading to a sustainable increase in food and agricultural production for the benefit of the indigenous population and to facilitate the spread of those techniques in the countries of the trainees;
- to promote development on internationally acceptable methodologies and techniques of desertification control, assessment, mapping and monitoring;
- to strengthen the capacity of national agencies in the various regions to apply such methodologies and techniques for desertification control, assessment, mapping and monitoring;
- to promote regional and international cooperation in anti-desertification activities through exchange of information, experience and training;
- to improve the capacity of countries concerned to deal with desertification issues by helping to increase the number of personnel in the area trained in desertification control, assessment, mapping and monitoring.

	Title	Place	Dates	Organized by	Number of participants
1	Workshop on the *Dryland Resource Management Project*	Aleppo, Syria	23-27 May 1993	ICARDA	33
2	Seminar on Mycorrhiza and their field application in afforestation programmes in North Africa (within AMCEN project)	Tunis, Tunisia	June 1993	UNEP/GBPNA/	12
3	The First Regional Workshop on Sustainable Land Use Management of Semi-arid and Sub-humid Regions (for Africa)	Dakar, Senegal	November 1993	SCOPE	35
4	Training Course entitled *Efficient Management for Sustainability in Arid Regions* (ESCAP region)	Jodphur, India	6-26 September 1993	CAZRI/UNEP	11
5	The Second Regional Workshop on Sustainable Land-use Management for Semi-arid and Sub-humid Regions (for America)	Oaxtepec, Mexico	Postponed to 1994	SCOPE	35
6	The third training course on Desertification Assessment and Control for LAC Countries	Mendoza, Argentina (IADIZA)	December 1993	IADIZA	22
7	Workshop entitled *Management of Salt Affected Soils for ACSAD and ESCAP countries*	ACSAD, Damascus Syria	October 1993	UNEP/ACSAD	23
8	The Third Regional Workshop on Sustainable Land-use Management of Semi-arid and Sub-humid Regions (for Asia)	Bangkok, Thailand	Postponed to 1994	SCOPE	35
9	Regional Seminar on Mangrove Rehabilitation	Myanmar, 1993	December 1993	ESCAP/UNEP	20

Key to Acronyms

ACSAD - Arab Centre for the Study of Arid Zones and Drylands
AMCEN - African Ministerial Conference on the Environment
CAZRI - Central Arid Zone Research Institute
ESCAP - Economic and Social Commission for Asia and the Pacific
GBPNA - Green Belt Project of North Africa
IADIZA - Instituto Argentino de Investigaciones de las Zonas Aridas
LAC - Latin America and the Caribbean
SADCC - Southern African Development Coordination Conference
SCOPE - Scientific Council on Problems of the Environment

Master plan to Combat Desertification in ECOWAS Member States

The Assistance Project funded by UNDP is a multi-disciplinary programme for strengthening economic cooperation and integration among West African States within the Economic Commission of West African States (ECOWAS). It consists of sub-projects carried out by UN agencies on trade (UN Commission on Trade and Development), monetary and financial cooperation (Economic Commission for Africa), transport, industry and energy (UN Industrial Development Organisation) and agriculture (UN Food and Agricultural Organisation), as well as desertification control/land resources management (UNEP)

According to the Inter-Agency Agreement signed on 14 May 1991, UNEP entered into cooperation with the Economic Commission for Africa (ECA) as Executing Agency to assist in the preparation of a Master Plan for the Coordination of Programmes to Combat Desertification in the ECOWAS sub-region.

The activities to be carried out by the consultants recruited by UNEP were as follows:

- Compile a complete inventory on desertification control activities in the sub-region;
- Assess the effectiveness of these activities;
- Prepare a Master Plan support programme to combat desertification in the Sahel and Coastal countries.

Drought and desertification have prevailed for two decades in Africa and are among the two most important environmental problems in the West African sub-region - mainly because of their damaging effects on the structure and functioning of national economies. The preamble to the Master Plan emphasizes relevant measures taken to combat desertification by such entities as:

i the International Community (adoption of the PACD during UNCOD 1977);

ii the African Heads of States within the framework of the Organisation of African Unity (OAU) - (Lagos Action Plan, 1988) and of ECOWAS (decade of reforestation, 1982, etc);

iii the African Ministerial Conference on Environment (the 1985 Cairo Programme of AMCEN).

Despite relevant measures taken to combat desertification in the sub-region, this phenomenon currently continues to spread in the West African dry sub-humid regions (North of Nigeria, Benin, Togo, etc) mainly due to deforestation activities. The Preamble points out that the Master Plan to Combat Desertification does not comprise any new projects and programmes, but rather aims at coordinating on-going programmes for combating desertification/natural resources management in the ECOWAS sub-region.

Institutions, Economics and the Environment

In the first section, the Master Plan analyses the capacity of institutions to integrate environmental policies on desertification and deforestation within the institutional, economic and environmental settings of the ECOWAS framework. In particular, it criticizes the lack of effectiveness, eg, in trade liberalization, industrial harmonization (coordination of industrial development policies), among others.

It further analyses the implication of institutional conflict of environmental policies, successes, failures and prospects of ECOWAS at regional integration and concludes finally that concentrating on purely economic objectives, ECOWAS can be a source of disagreement between its members. To reduce tension, it is necessary to focus on other broader objectives, such as environmental issues, on which it might be relatively easier to strike a balance and secure consensus.

As far as the outline of strategies, plans and programmes to combat desertification/land resources management in the ECOWAS sub-region, is concerned, it was noted that many Environment Protection/Natural Resources Management are being developed in West African countries, namely:

i Environmental Action Plan (EAP) initiated by World Bank;

ii Tropical Forestry Action Plan (TFAP) initiated by FAO/UNDP;

iii National Plan of Action to Combat Desertification (NPACDs) supported by UNEP;

iv National Conservation Strategy (NCS) sponsored by IUCN, UNEP and WLF;

v Natural Resources Management Plan (NRMP) sponsored by World Bank/UNDP/USAID, etc.

It is hoped that solutions would be found, first, at national level by coordinating and harmonizing these different strategies, plans and programmes which, in most cases, are either overlapping or contradictory in their objectives or scope; and secondly by integrating them into National Development Plans.

The responsibilities of donor countries, UN agencies and the World Bank with regard to the multiplicity of strategies and programmes are pointed out in the Master Plan. It suggests that better coordination of the relevant activities of such organizations and donor countries would be required.

Existing Sub-regional Conditions Reviewed by the Master Plan

1. Agriculture, *lato sensu*, natural resources conservation and protection of remaining forests. It is suggested that a natural resources accountancy should be carried out in order to demonstrate how the impact of development activities has affected natural resources and led to a rapid degradation of the environment in the West African States.

2. Economic aspects of the struggle against desertification including debts' reduction or cancellation, transfer of existing and potential technologies to combat desertification;

3. National programmes to combat desertification/natural resources management in the ECOWAS Member states, particularly in Benin, Burkina Faso, Ivory Coast, Ghana, Mali and Senegal.

Some preconditions for efficient programme implementation are reiterated, such as curbing or reducing population growth, promoting the consumption of local farm produce and trading activities within the West African Sub-region, a comprehensive physical planning policy and development policies for rural communities.

The ECOWAS Master Plan suggests that promoting agroforestry to combat desertification in West Africa should be one of the solutions to be encouraged. It further notes, in the chapter entitled *Hope in the Sahel*, that despite difficulties all is not negative in West Africa. Some success stories in desertification control are quoted in Niger, Mali, Mauritania, Burkina Faso and Senegal.

The Master Plan for the Coordination of Programmes to Combat Desertification/ Natural Resources Management in the ECOWAS sub-region proposes:

i *a three years preparatory phase* during which actions should be implemented at:

1 National and sub-regional levels involving governments and ECOWAS, consisting of an indepth review, analysis and evaluation of all on-going projects, strategies and programmes to combat desertification/ land resources management. It is also suggested that all of these projects, strategies and programmes be merged into one single strategic exercise in the framework of a future sub-regional Master Plan to combat desertification, integrating the objectives of Agenda 21 and with the endorsement of UN organizations (UNEP, FAO, UNESCO, etc)

2 Local level, rural populations will be responsible for undertaking precise assignments in the following areas:

i Water resources;
ii Soils management;
iii Energy and ground cover plants;
iv Animals husbandry.

Transnational projects have been proposed for specialization in agronomy, sciences and agroforestry. A minimum priority, development programme is proposed on a short, medium and long term basis in the four sectors considered below, both at national and sub-regional levels.

The Draft Master Plan proposes a strategy to implement projects and programmes with the following measures:

i Political declaration of ECOWAS Heads of States introducing the concept of a Master Plan to combat desertification in the ECOWAS member states to the International Community, donor countries, non-governmental organizations, etc;
ii Restructuring and reinforcing ECOWAS technical departments to enable them to ensure the coordination and follow-up of the implementation of the Master Plan;
iii Reinforcing the sub-regional intergovernmental institutions and organizations with the aim of coordinating their utilization;
iv Promoting greater awareness and consequent involvement of decision-makers in the integration of desertification control/natural resources management in development programmes and national action plans;
v Stimulating the involvement of grassroots operators and NGOs in planning and implementing desertification control/natural resources management programmes.

To conclude, the Master Plan attempts to tackle the important desertification issues in priority areas of sensitive sectors at local, national and sub-regional levels, and proposes action-oriented solutions in areas of concern.

Particular attention is drawn to the fact that the Master Plan to Combat Desertification in ECOWAS Member States is neither exhaustive or definitive since only 9 out of the 16 ECOWAS Member States were visited by experts.

BOOK REVIEW

Nomadic Pastoralists in Kenya.

Human-Ecological Aspects of the East-Pokot
Institute for African Studies, Serial No 83
(Institut für Afrika-Kunde)
Hamburg/GERMANY
167 Pages - Published in 1992
Arbeiten aus dem Institut für Afrikakunde 83

by Ute Reckers

The theoretical basis for this study is the human-ecological concept which analyses the relationship of 'man and biosphere' from a historical, ecological and environmental (in a regional, political, socio-economical and cultural context) perspective.

The life of nomadic pastoralists obviously presents a close entanglement between humans, livestock and the environment. As a result of interviews with the East-Pokot people about their daily life struggle, the author was able to elaborate clearly how the natural habitat and man - including his way of life and economic basis - do have an influence on each other. On the one hand, the ever-changing climate demands a direct and flexible reaction from man, eg. more mobility. On the other hand, through careful manipulation humans are able to transform their environment according to their needs. For example, the East-Pokot use rotational grazing and controlled burning of pastures to prevent their pastures from being taken over by bushes (so-called 'green desertification'), which makes pastures useless for livestock.

The first chapter of this publication gives an introduction to the general field of *Nomads and Environment*. The current reality of a nomad's life in relationship to his environment is described. The study is based on the thesis that nomadic pastoralists do not act irrationally concerning the environment. The East-Pokot are an example of many nomadic peoples who are quite aware of their environment and are able to preserve the scarce resources of the area. Their traditional strategies of flexibility, which have proved successful for centuries, are fully adjusted to the conditions of the Sahel.

The second part of this publication provides detailed definitions of the terms *Sahel/Savanna*, *Nomadism* and *Pastoralism*.

In the third chapter the physical features of the area of the East-Pokot in Baringo District are presented.

The fourth and fifth parts deal with the social organisation and political structure of the East-Pokot as well as with their economy and landuse system. All these subjects are compared to the past which an provides explanation for the cultural, economic and landuse changes.

The last chapter comprises all the preceding information and focuses it on the core question of adaptive survival strategies.

It is the East-Pokot's mechanisms for adapting to their environment that are the important subject of the study because these traditional practices help them to survive on several levels. *Survival* in this context does not only mean pure physical survival, but also economic survival and socio-cultural survival (way of life).

The traditional strategies have either a mainly equalizing function (mobility, herding management) or a primary preserving function (resource control in range management). In times of needs, such as drought, pastoralists are flexible enough to transform these strategies for daily life struggle into survival strategies. Indeed, flexibility is the key factor behind pastoral strategies.

On the whole, traditional strategies - in that they are meaningful, functional and efficient - among the East-Pokot still appear to be very significant elements of the nomadic system.

The fact that the nomadic lifestyle today is more and more limited and comes into conflict with the carrying capacity of the area cannot only be put down to the fault of the nomadic system itself, or by the emergence of socio-cultural changes within the nomadic society, or even by climatic fluctuations in semi-arid lands. It is primarily the consequence of external developments out of the sphere of influence of nomadic pastoralists. The main problems are population pressure from the central regions in Kenya into the semi-arid zones which is provoking increasing scarcity of land. As a result, the traditional nomadic strategies are gradually loosing their function because they cannot or can only in part be applied. For example, today pasture areas can no longer be expanded according to needs, due to pressure on limited land resources.

Finally, this publication proposes some measurements for development aid work although it keeps in mind that it is not merely a question of preserving a romantic image of traditional nomadic life styles. Whether new investments into the traditional system are desirable or not depends on the ability of the nomadic system to survive without too much help from outside. The question is how seriously the nomads take their strategies today and, of course, whether they still accept and are willing to keep this lifestyle.

Environmental Guidelines for Halophytes as a Source for Livestock and for Rehabilitation of Degraded Land

Halophytes are plants which have the ability to grow and complete their life cycle on salt-affected soils and some of them could be grown with waters with salinities as high as ocean water. Soils regarded as wasteland

and having high salinity and/or sodicity levels can be grown with halophytes. Halophytic vegetation can provide the following benefits:

- soil erosion control;
- ecosystem enrichment and general environmental improvement;
- profitable forage yields;
- reduced pressure on other lands; and
- growth of halophytes in dry areas could make a significant contribution to the reduction to the reduction of greenhouse gasses.

The purpose of the Guidelines is to assist planners administrators and officers in the field in the successful use of halophytes as a resource for livestock and for rehabilitation of degraded lands.

1994 United Nations Environment Programme, obtainable early 1994 from: UNEP, TEB, Soils.

World Map of Present-day Landscapes

Scale 1:15,000,000
Edited by E. V. Milanova and A. V. Kushlin (Faculty of Geography, Moscow State University, Russia) with assistance from N. J. Middleton (School of Geography Oxford University, U.K)

The Map was compiled by research staff of the Department of World Physical Geography and Geoecology, Faculty of Geography, Moscow State University (MSU) in the framework of the UNEP/MSU Memorandum of Understanding. The map is based on a complex approach to the environment as a combination of hierarchically subordinated geosystems called "present-day landscapes". Each present-day landscape is a distinct unit of land surface characterized by a combination of natural and anthropogenic forces which have together molded a spatially distinct territorial system in dynamic equilibrium. Hence the present-day character of any landscape unit can be seen as the result of anthropogenic transformation of its natural basis.

The notion of "present-day landscape" corresponds to the notion of "land" accepted at the UNEP Ad-Hoc Consultation Meeting "Assessment of Global Desertification: Status and Methodologies" (Nairobi, February 1990) as an object of desertification studies. By stressing the natural foundation of particular landscapes, the present-day landscape concept encourages the researcher to be aware continually of the fact that in order to achieve optimal environmental management, all economic structures and processes must be compatible with the dynamic equilibrium of natural structures. Ignoring this principle is often the major cause of environmental problems, including desertification.

The map results from synthetic generalization and analytical re-processing of global wall-charts from the World Thematic Series (MSU, 1986, 1988). Space images (i.e. Landsat TM, Cosmos-1939, NOAA AVHRR) have been used to evaluate data reliability and to fill information gaps.

An initial categoric division is made between landscape units deemed to be "modal" (natural landscapes that have not been affected by human modification) and "natural-anthropogenic" (landscapes thought to have been significantly affected by human action). Factors indicative of a landscape unit's natural character include such characteristics as relief, soils, and potential natural vegetation communities. The degree of landscape transformation is determined by changes of vegetation cover and actual land use. Three classes of natural-anthropogenic landscape are recognized, according to the degree of effect: derivative, landscapes, landscape anthropogenic modifications, and landscape technogeneous complexes.

Using this system, every mapping unit can be considered as a objective inventory cell furnished with data on the state of the present-day natural and socioeconomic landscape. The map also facilitates comparison of the results of similar economic impact within different natural environments, which is indispensable to the comparative analysis of landscapes' variability and definition of their optimal structure and pattern.

The map will be available at the beginning of 1994.

Success Stories in Desertification Control

The UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in June last year has rekindled the interest of the World Community in the problem of dryland degradation (desertification) and its control. An International Convention is being prepared and negotiated on Desertification and Drought. *Desertification* as defined by UNCED is *land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.*

In the last decade, many national, regional and international projects have been launched in many parts of the world, with the aim of controlling dryland degradation (desertification). Much has been heard about the projects which have failed, but there have also been successful projects which have contributed substantially to the control of dryland degradation (desertification). Unfortunately these have received much less attention. If these *successes* could be better publicized, these positive experiences could contribute tremendously to educate people 'how to do things right' in desertification control. This could not only answer the question of what *can* be done, but also help create a renewed mood of confidence that the problem of desertification can be conquered! With this in mind, early this year UNEP DC/PAC initiated the collection and documentation of successful stories in desertification control with the aim of:

- establishing a success story databank centre at DC/PAC (to be continuously updated);
- creating public awareness of the existence of successful projects/activities in desertification control; and
- encouraging the emergence of successful projects and reports on them, firstly, by giving 'Effective Action Against Desertification Awards' to those that excel and, secondly, by giving wide publicity to the successful undertakings in order to build confidence that it is feasible to combat desertification.

A 'success' in desertification control is considered to be an action (or project) which directly or indirectly contributes substantially to the prevention of dryland degradation or to the reclamation of degraded/desertified land, using appropriate resources in a cost-effective manner and is sustainable over a long period of time.

Over 6,000 contacts have been made, through mail and advertisements in the globally-distributed Environment Liaison Centre International (ELC) newsletter, *Ecoforum*, requesting submissions on success stories.

We would be most grateful if you could kindly help us to achieve our goal by nominating any of your projects that have contributed substantially to the control of dryland degradation (desertification) and which you feel has been a success.

We hope you will be kind enough to respond positively by sending us as many of your success stories as possible so that we may share your positive experiences with others involved in desertification control around the world.

We see your contribution as the first step in an ongoing process. The next step will be to carry out a summary of those projects which are proposed. The subsequent phase is to design and carry out an evaluation of those proposed with the aid of supporting reports from project referees.

In an attempt to define success, we have drafted criteria which we propose to use in evaluating the 'success' of the proposed projects (available on request). We would welcome your comments or suggestions/additions to these criteria so that we can use your input for evaluating the projects at a later stage.

Details on how to nominate your project and other information are also available on request.

By mid May, 63 success stories had been nominated and more were coming in daily. These included 32 entries from Africa (Senegal, Burkina Faso, Mali, Mauritania, Togo, The Gambia, Cape Verde, Guinea Bissau, Kenya, Somalia, Sudan and Namibia); 30 entries from Asia (China, India, Pakistan, Indonesia, Russia and Australia); and one from North America (USA).

The collection and documentation of success stories in desertification control at UNEP DC/PAC is a continuing activity. We shall, therefore, continue to welcome submissions on successful initiatives in this field without any deadline.

Success stories should be submitted to:
Mr W. Franklin G. Cardy
Deputy Assistant Executive Director
Director DC/PAC
UNEP
PO Box 30552
Nairobi, Kenya
Fax: 254-2-215615

CONFERENCES

Listening to the People

Chapter 12 of Agenda 21 has proposed a revised approach to the problem of halting dryland degradation, also known as desertification. After many frustrations and failed projects, it is becoming increasingly apparent that previous approaches have overemphasised technology at the expense of people at the field level. Science and technology are still important, but many experts now believe that a radical shift is needed by governments and donor agencies to incorporate community participation and traditional knowledge systems into programme and project conception, formulation and implementation. Chapter 12 recommends that this be done.

Nothing new? Local community participation has been a buzz word for many years in the development business, but to implement it is easier said than done. Bureaucracies have had great difficulty in bridging the gap between their own rules and ways of operating at a large scale and the small scale, idiosyncratic behaviour of local communities. NGOs and academic researchers, and even some of the larger donors, have achieved much over the past few years in developing methodologies that aim to bridge the gap. The Desertification Control PAC wants to make use of this acquired knowledge in planning its own programme of future activities and in promoting its use by other organisations and governments.

So from 14 to 18 December this year an international workshop on 'Listening to the people: Social aspects of dryland management' will be held here at Gigiri. Representatives of community and international NGOs, research institutions, donor agencies and governments will be brought together to discuss issues related to natural resource management and sustainable development in the drylands. The main purpose is to produce a series of recommendations for concrete action that can be taken by all interested parties, focusing on how local communities can be assisted to manage their own natural resources.

Various participatory approaches to project appraisal, research, extension services, land-use planning and land management will be addressed by people who have been developing the methodologies in the field. Issues of gender equity and decision-making, land tenure, access to resources, local empowerment, indigenous knowledge systems, government policies and responsibilities vis-à-vis local communities, and the rôle of donor agencies will be explored. Since top-down approaches have been shown to be one of the major causes of project failure, how can decision-making and information flow start at the bottom - i.e. local communities - and make it to the top, to the senior government officials and donor agency managers who make policy and determine procedures?

The objectives of the workshop reflect the shift in view from seeing desertification control simply as a problem of applying technological fixes - tree planting, terracing, water harvesting, rotational livestock grazing, etc. - to one of communities creating the necessary institutions and mechanisms to enable them to manage their resources in a sustainable manner. There are success stories, but we need many more of them. This workshop should show us the way to achieving them.

COURS INTENSIF SUR

LE FONCIER ET LA GESTION DES RESSOURCES NATURELLES EN AFRIQUE SUB-SAHARIENNE

14 Février - 4 Mars 1994

Land Tenure Centre
University of Wisconsin-Madison
USA

Institut des Sciences de
l'Environnement/Université
C.A. DIOP de Dakar
Sénégal

Le foncier, en organisant la répartition des droits relatifs à la terre, aux forêts, aux pâturages et aux autres ressources naturelles, apparaît comme us facteur de plus en plus important dans la gestion des ressources naturelles. Les droits d'usage et la sécurité foncière influencent fortement l'investissement dans l'agriculture et l'adoption de pratiques viables de gestion des ressources. Le mode d'appropriation définit le rôle des diverses institutions sociales et politiques dans la manière de réglementer l'utilisation des ressources naturelles, aussi bien celles se situant au niveau des exploitations agricoles, que celles utilisées de manière collective comme les forêts et les pâturages.

Les systèmes fonciers africains sont divers et les droits à certaines ressources sont souvent partagés entre l'Etat, les communicautés locales et les usagers individuels. Les modes d'appropriation subissent des mutations importantes du fait des changements socio-économiques et des réformes foncières engagées par les Etats. La mise en place de politiques foncières appropriées figurera parmi les aspects-clés des stratégies nationales pour améliorer la gestion des ressources naturelles.

OBJECTIFS ET CONTENU DU COURS

Le cours vise deux objectifs fondamentaux:

1. Apporter aux participants(es) une connaissance et une compréhension assez larges des modes d'appropriation et des politiques foncières en vigueur, surtout en Afrique Sahélienne, et de leurs impacts sur l'utilisation et la gestion des ressources.

2. Initier les participants(es) à la Méthode Accélérée de Recherche Partipative (MARP ou RRA) sur la foncier et les modes d'appropriation.

Parmi les thémes majeurs qui seront étudiés dans le cadre de ces deux objectifs, on peut retenir:

- i) les principaux modes de gestion de la terre et des ressources naturelles en Afrique sub-Saharienne et en particulier Sahélienne. L'historique des politiques et réformes foncières avant et après les Indépendances;
- ii) les questions-clés de la gestion des ressources naturelles en Afrique sub-Saharienne. Causes et dynamiques de l'érosion du sol, de la dégradation des parcours pastoraux, de la déforestation et de la perte de bio-diversité;
- iii) les perspectives économiques liées aux modes de gestion des ressources naturelles. Interrelations entre sécyrité foncière, mécanismes de décision des usagers et rendements économiques;
- iv) la gestion des ressources communautaires. Modèles et études de cas d'une gestion commune des pâturages, des forêts et des ressources halieutiques;
- v) la gestion des arbres et des terres comme facteur-clé dans l'adoption de pratiques agroforestières et de programmes de bois villageois;
- vi) la gestion des ressources par l'Etat. Législation environnementale en Afrique sub-Saharienne, aménagement de l'espace et gestion du terroir;
- vii) la répartition des droits sur la terre et la question des fonctions différentielles entre hommes et femmes dans la gestion des ressources;
- viii) les droits de chasse, les réserves forestières et les espèces menacées. Le rôle du mode de gestion dans la mise en oeuvre des politiques de conservation;
- ix) démographie et modes d'appropriation et de gestion des ressources naturelles. Influence de l'accroissement de la population sur les systèmes fonciers;
- x) le foncier péri-urbain: logiques contradictoires des stratégies d'occupation spontanée et d'aménagement volontaire de l'espace péri-urbain.

CONDITIONS D'ADMISSION

Le cours s'adresse aux africains(es) francophones responsables de la mise en oeuvre de politiques de gestion des ressources naturelles et d l'élaboration de projets. Il s'adresse également aux chercheurs en sciences humaines, juridiques ou économiques. Les participants(es) devront avoir au minimum l'équivalent de la maîtrise (4 ans d'études supérieures après le baccalauréat).

STRUCTURE DU COURS

Le cours se déroulera sous forme de conférences, ateliers et travaux individuels de documentation et comptes-rendus de lecture. Des études de cas permettront de faire en aprmanence le lien entre la réalité de terrain - grâce à la Méthode Accélérée de Recherche Participative - et les questions théoriques et méthodologiques (alternance terrain-salle de classe).

Il est attendu que chaq'un participe activement dans la préparation d'une étude de cas sur la situation foncière d'un terroir villagois aux alentours de Mbour. Les petites équipes dirigées par un encadreur passeront plusieurs nuits au village.

ENCADREMENT

Le cours se déroulera sous la supervision de charcheurs/professeurs du Land Tenure Center et de l'Institut des Sciences d l'Environnement. Il bénéficiera de l'appui de spécialistes venant de l'Afrique francophone, de l'Amérique du nord et de l'Europe.

DATES

14 Février au 4 mars, 1994 (3 semaines).

LIEU DE FORMATION

Les participants(es) seront pris(es) en charge (logement et nourriture) pendant toute la durée du cours, au centre sidou Nourou Tall. Ce centre de formation de l'ENDA Tiers-monde se trouve à Mbour, à environ 80 Kilomètres de Dakar.

COÛTS PAR PARTICIPANT(E)

Encadrement	$2,670
Frais de séjour	$1,480
Assurance	$ 50
Total	**$4,200**

Ces frais d'inscription incluent l'encadrement (professeurs et chercheurs), le matériel didactique, les séjours aux villages environnants, le logement et repas au centre d'accueil, le transport local et, au besoin, le logement dans un hotel à arrivée et au départ du participant pour deux nuits au total. Veuillex noter que ce montant ne couvre pas les frais de voyage aller-retour du lieu de résidence à Dakar.

NB: Les organisateurs du cours ne verseront ni per diem ni argent de poche; celui-ci doit faire l'objet d'une négociation entre le candidat et son organisme baileur.

Veuillez demander à votre commanditaire d'écrire une lettre de prise en charge au Land Tenure Centre indiquant les modalités de paiement de vos frais d'inscription au plus tard le 1 janvier, 1994. Le participant(e) est chargé de fair parvenir son inscription en totalité, par chèque bancaire de préférence, au bénéfice du Land Tenure Center le 1 février, 1994.

DATES D'INSCRIPTION ET COMMUNICATIONS

Dr Mark S. Freudenberger
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University of Wisconsin-Madison
1357 University Avenue
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Téléphone: (608) 262-3657
Fax: (608) 262-2141
e-mail: landtenure.center@mail.admin.wisc.edu
Télex: 265452 - Attn: Land tenure

INSTITUTIONS ORGANISATRICES

Le Land Tenure Center (LTC)

Le Land Tenure Center de l'Université du Wisconsin à Madison a été créé en 1962. Ses programmes sont orientés vers l'étude des questions interdisciplinaires relatives aux systèmes fonciers, aux réformes foncières et aux questions institutionnelles associés au développement rural. Le centre gère un programme intégré de recherche, d'enseignement, de publication et d'assistance technique.

L'Institut de Sciences de l'Environnement (ISE)

L'Institut des Sciences de l'Environnement est un institut d'enseignement et de recherche de niveau 3éme cycle de la Faculté des Sciences et Techniques d l'Université Cheikh Anta Diop de Dakar dont il dépend au plan académique et administratif. L'ISE a été créé en 1978 en vue de promouvoir une gestion rationnelle du milieu; il a pour mission de former des cadres de terrain capables d'identifier les composantes principales de l'environnement, leurs interactions ainsi que les techniques modernes de leur évaluation. Ces cadres seraient ainsi capables de participer, en équipes interdisciplinaires, à la définition et à la définition et à l'application de politiques de développement durable.

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities *

** This latest, Internationally negotiated definition of* ***desertification*** *was adopted by the UN Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil, in June 1992.*

UNEP

Desertification Control Bulletin

United Nations Environment Programme