United Nations Environment Programme

ISSN 0379-2455

Desertification Control Bulletin

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

Number 28, 1996

UNEP

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Cover: It is possibe to stop moving dunes with palisades and tree planting, but the seedlings have to be watered and often there is no water. It is thus very hard to stop desertification in these areas. Photo: Jòran Fries, Sweden.

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. In 1995 DC/PAC broadened its base of activities to become the Dryland Ecosystems and Desertification Control PAC (DEDC/PAC). DEDC/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.

Audiencez

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 and Spanish. 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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Summary of the Eighth Session of the INC of the Convention to Combat Desertification

5 - 15 February 1996

The Intergovernmental Negotiating Committee of the Convention to Combat Desertification (INCD) met for its eighth session in Geneva, Switzerland, from 5 to 15 February 1996. The INCD is currently functioning during the interim period between the conclusion of the Convention and its entry into force and is preparing for the first Conference of Parties (COP).

During the course of the session, delegates reviewed the status of ratification, the situation as regards extrabudgetary funds, and the implementation of the resolution on Urgent Action for Africa, as well as action in other regions. The working groups dealt with preparations for the first Conference of the Parties, which is expected to take place in about 19 months. Delegates began negotiations on crucial issues, including the global mechanism, the designation of a Permanent Secretariat and arrangements for its functioning, financial rules and the rules of procedure. While the meeting was criticized for making little progress in taking decisions, important steps were taken on the organization of scientific and technological cooperation.

A brief history of the INCD

Desertification affects about one-sixth of the world's population, 70 per cent of all drylands, and one quarter of the total land area in the world. The most obvious impact of desertification, in addition to widespread poverty, is the degradation of 3.3 billion hectares of the total area of rangeland, a decline in soil fertility and soil structure, and the degradation of irrigated cropland. The Convention to Combat Desertification (CCD) was formally adopted on 17 June 1994, and opened for signature at a ceremony in Paris on 14 and 15 October 1994. This first post-Rio sustainable development convention is notable for its innovative approach in recognizing: the physical, biological and socio economic aspects of desertification; the importance of redirecting technology transfer so that it is demand driven; and the involvement of local populations in the development of national action programmes. The core of the Convention is the development of national and subregional/regional action programmes to combat desertification. These action programmes are to be developed by national governments in close cooperation with donors, local populations and non-governmental organizations (NGOs). To date, the Convention has 115 signatories and has been ratified by 25 countries. The CCD will enter into force 90 days after the receipt of the 50th instrument of ratification.

Intersessional highlights

50TH SESSION OF THE UNITED NATIONS GENERAL ASSEMBLY: The 50th United Nations General Assembly considered Agenda Item 96 (a), Environment and Sustainable Development: Implementation of Decisions and Recommendation of the United Nations Conference on

Environment and Development, on Monday, 30 October 1995. In connection with this item, the General Assembly had before it a number of documents, including the report of the Secretary-General on desertification and drought (A/50/347), and a note by the Secretary-General transmitting the reports of the INCD on its sixth and seventh sessions (A/50/74 and Add.1).

The resolution adopted by the General Assembly decides that the INCD will continue to prepare for the first COP and, for this purpose, will have two sessions in 1996, each of up to two weeks duration. The resolution also sets the tenth INCD session in New York from 6 to 17 January 1997 and, pending the entry into force of the CCD, to convene, as necessary, a further session in 1997. Upon entry into force of the Convention, a COP will be convened during the second and third weeks of June 1997 or, alternatively, during the second and third weeks of August 1997. The resolution also requests governmental, non-governmental and other interested groups to take action upon entry into force for the prompt implementation of the CCD and its relevant regional annexes; urges all countries and relevant actors to take actions to implement the resolution on urgent action for Africa; decides that the work of the INCD and the Interim Secretariat will continue to be funded through existing United Nations budgetary resources; and urges States and interested organizations to contribute to the trust for the Interim Secretariat and the special voluntary fund for the participation of developing countries. The resolution welcomes the arrangements concluded between the Interim Secretariat and the International Fund for Agricultural Development (IFAD) and the World Meteorological Organization (WMO) to support activities in affected developing countries and invites the Interim Secretariat to conclude similar arrangements with other relevant organizations, such as UNDP, UNEP, FAO and UNESCO.

A brief analysis of INCD-8

At the end of the two-week session, the modest achievements induced divergent views. Experienced negotiators had arrived with low expectations and seemed to think that the lack of decisions was a natural ingredient in the negotiation process. Some left feeling disappointed while others were positive and said remaining work could warrant an 11th INCD session.

Most delegates agreed that negotiations moved slowly and pointed to common reasons for the pace. Progress occurred when preparation and key people happened to coincide at the right point in negotiations, as in discussions of the Committee on Science and Technology (CST). When these factors were lacking, particularly concerning sensitive financial matters, negotiations halted and gave way to relatively limited activity in the form of consultations within or between regional groups. Without negotiating texts, and with delegations unwilling or unable to concur on the presentation of possible negotiating texts, little happened.

Some delegates noted that the pace was slow because of incomplete organization within regional groups. This was not surprising. In fact, at the last session, developing countries expressed a preference for holding this session in New York where the G-77 is better organized. Another explanation was that documents reached delegates late, preventing some regional groups from greater coordination prior to their arrival in Geneva. Expectations for substantive achievement were higher than at INCD-7, when many delegates felt a general exchange of views was sufficient for that stage in the INCD process. At INCD-8, the lack of negotiations in some areas caused one delegate to say that compared to Nairobi, there was no "passion" in Geneva. The pace became a motivation behind OECD proposals to restructure and shorten future INCD sessions. Financial concerns related to the UN's budget crisis were another undercurrent beneath many INCD-8 discussions. These concerns were a key element in curtailed debates on the Permanent Secretariat and, to a certain extent, programme and budget.

Delegates pointed to the interrelationship with other conventions as the final limiting factor on the work of INCD-8. Negotiations on CCD's rules of procedure and financial rules cannot overtake negotiations on similar subjects in the Climate Change and Biodiversity Conventions, because those conventions are in force and some delegates say the procedural debates should be resolved across the treaties. Constant references to precedent caused some delegates to dought whether the CCD has the same status as these other two conventions. Another cause of concern during the session related to the debate on Urgent Action for Africa and action in other regions. While the Chair said the objective was to provide information on what is happening and to learn lessons for further implementation, many delegates disagreed with the manner in which the debate was organized and the way in which issues were presented.

The proportionately large amount of time allocated to the African region led some delegates to question the amount of attention granted to other regions. Some observers argued that it was because of numerous complaints by delegates from the non-African developing regions at INCD-7 that accelerated activity in these regions had taken place. The possible influence of reports in the sessions on implementation becomes more critical in light of proposals that would re-organize work in a way that marginalizes the reporting sessions.

Some observers and delegations see the reporting session as important, but affected and donor countries alike voiced frustration over each other's overly general statements. Some delegates said negotiators should address the inability of governments working in the same regions to achieve partnership instead of viewing the reduction of reporting sessions as the solution.

Informally, developing country delegates said that partnership building, which donors want them to initiate was difficult to attain. They say staff from donor countries never turn up for meetings and are unaware of the CCD and processes of accessing funds. Developed countries responded that desertification is not mentioned as a priority when they conduct missions to affected countries. In some instances, even where new funding has been set aside, requests have not yet been received. This points to poor information flows and lack of national political will in both cases, which both sides say have slowed progress. As processes of consultation and coordination are still not well understood, greater consideration should also be given to the negotiations on the agenda item on communication of information and reporting. The type of information donors think is useful and what developing countries feel is needed should be used as a basis to define a set of parameters that can be used to measure progress.

Two regions revealed gaps that could affect the implementation of the CCD. The division of Africa into subregions left Rwanda, Burundi, the Central Africa Republic and Cameroon isolated. This prompted Cameroon to suggest that a subregional body should be designated with responsibility to assist Central Africa in CCD implementation. Some delegates were quick to point out that the absence of a subregional body may indicate that the problem does not exist there. Others noted that coordinated efforts are needed in the Central African countries if the problems of drought and desertification are to be dealt with effectively in Africa.

The Russian Federation stunned many delegates with the announcement that it is unlikely to ratify the Convention in view of the Convention's omission of countries with economies in transition. Although some delegates were sympathetic to their situation, they said the pursuit of a regional annex during the negotiation of the Convention would have been the best option. Given the current circumstances, some delegates thought that pursuing the matter within the United Nations General Assembly would be more promising.

On a positive note, the negotiations on scientific and technological cooperation seemed to be the one area where delegates could point to progress. Discussions moved beyond details such as whether experts in the CST would have to provide CV's, a topic at INCD-7. Delegates sought means to most effectively tie the CST and the ad hoc panels to the COP, emphasizing that the CST is subsidiary to the COP. Delegates wanted to keep the CST, its Bureau and the ad hoc panels small and efficient, yet demands for geographic, multidisciplinary, gender, NGO, and IGO representation may complicate selection of ad hoc panel members. Considerable time was spent on discussing the availability of information, with an emphasis on NGO representation to provide local knowledge and expertise. The agreement that the results of the work of the CST "shall be in the public domain" may provoke discussion at INCD-9.

NGOs praised delegates' prioritization of local knowledge and expertise and NGO participation as a sign that participation, a central principle of the Convention, is being written into implementation structures. NGOs had targeted CST deliberations at INCD-8 with some success, getting their proposals for attention to focus on women, local peoples, and traditional and local knowledge and technology incorporated and adopted by the governments. Some have observed that collaborative initiatives between national governments and NGOs formed the basis for the NGOs' success. Others noted that good organization, coordination and pointed interventions made the difference.

The areas where the least progress occurred were negotiations on the Global Mechanism (GM) and the financial rules. The causes can be attributed to the same factors. Delegates said documents on the GM were distributed late, limiting preparation of positions prior to the meeting. The documents discussed in this and other subjects were compilation texts rather than negotiating texts, triggering manoeuvres around whose basic document would become the negotiating text. Unlike during the negotiation of the CCD when the G-77 and China, and in particular Africa, set the pace by providing draft text and consolidating positions well in advance, at INCD-8 they only managed to develop a concerted position on the GM on the last day of the session. Individual participation, or lack thereof, played a part as well. Some delegates noted that key negotiators with leadership and a historical perspective on the financial issues were missing along with their knowledge and ability to move negotiations forward. Delegates say two visions of the GM are emerging. One, supported by many developing country delegations would establish a central fund with its own resources. The other, described by OECD delegates would provide motivation and be an information source that would leave funds in existing bilateral funds. These functions are critical to the Convention's implementation and countries' decisions on ratification, so delegates say the decision cannot be rushed. Some observers noted that the extensive regional group consultations on the GM, Kjellén's comments to give priority to the GM during the intersessional period and future sessions, and the divergence between the OECD and the G-77 and China indicate the challenges that lie ahead.

Steps toward regional coordination and a negotiating text during the intersessional period will be critical. In spite of these setbacks, many delegates and observers believed that INCD-8's work could contribute to more substantive work at the next session. The new additions to the bureau, progress on the CST and the consolidation of regional positions on the GM may allow INCD-9 to conduct more detailed negotiations. Furthermore, if the ratification process continues at its current rate, delegates will have to increase their pace. However, forces beyond the INCD's control could also have significant effects. Constraints resulting from the United Nations budget crisis could continue to delay decisions, while procedural issues could gain if progress occurs in other negotiations. The full impact of these changes will only be seen at INCD-9, which is scheduled from 3 to 13 September in New York.

This report was compiled from the special issue of *Earth Negotiations Bulletin* published by the International Institute for Sustainable Development (IISD), with the support of UNEP. This report is printed without prejudice and in the understanding that any views expressed herein are not necessarily those of UNEP.

World Day to Combat Desertification and Drought

Four years ago in Rio de Janeiro, the leaders of 150 countries called for the preparation of an international treaty to combat desertification.

Negotiations began in Nairobi in May 1993 and were completed on June 17 1994. Recognizing this as a way of drawing increased attention to the severity of the problem of desertification and the need for effective action to combat it, the General Assembly designated 17 June as World Day to Combat Desertification and Drought.

All over the world special events are planned to mark the day and to highlight the need for urgent action to be taken on desertification.

The theme of the 1996 World Day to Combat Desertification and Drought was "Bridging the Gaps". The gaps that exist in our understanding of desertification and also the gaps in our understanding of the knowledge, abilities and perspectives of others. This reflects the Convention's insistence on community involvement and the bottom-up approach"

Ms Elizabeth Dowdeswell, Executive Director of UNEP, Mr Franklin Cardy, Director, DEDC/PAC, UNEP and Mr Fredrick Lyons, UNDP Resident Representative in Kenya at the opening ceremony for World Day to Combat Desertification and Drought. Photo: UNEP

As a predominantly dryland country, much of Kenya is at risk from desertification. The result for inhabitants of these areas is poverty and food insecurity. Therefore Kenyans have a special interest in the early ratification and successful implementation of the Convention and on the spread of sustainable land management practices.

One of the problems in the past has been that desertification control was perceived as a narrow sectoral, technical issue, a subset of agriculture. What is required is a comprehensive approach to the overall management of the drylands.

At the United Nations Environment Programme we are working to generate a wider understanding of what is needed to maintain that development.

Over the last three decades, projects have been launched throughout the world, with the aim of controlling land degradation and desertification.

This does not mean top-down planning and centralized management by executive order. It means the reverse. The front line troops in the battle against desertification are the farmers, often women and children, struggling to scrape a living from a hostile environment.

In most of the drylands they have gained the skills to do this successfully over the centuries. In normal times the challenge is something they can handle. They have developed skills for sustainable management, adaptability, risk assessment, and insurance that need wider recognition and dissemination. That is part of our job at UNEP.

Students from the Aga Khan School, Nairobi, participating in the Schools' Forum on World Day to Combat Desertification and Drought.

The drylands are felt to be so important that UNEP has decided to create a specific award to recognize outstanding dryland activities, the "Saving the Drylands" award.

This honours individuals, communities or projects that have made an outstanding contribution to desertification control. Our hope is that the award will help instill confidence in people that degraded lands can be rehabilitated and made sustainably productive once more.

The first-ever "Saving the Drylands" awards were given last year to eight successful projects and individuals. Five of these were community-level activities in which the community members participated in all stages of development with tangible benefits being shared equally.

This year we presented two such awards to community projects, one in the drylands of Sudan and the other in India, which have demonstrated outstanding achievements. As a result of these projects the two communities have been able to better manage their environments and sustainably enrich their lives.

Through soil and water conservation measures and afforestation the Jhanwar Watershed Project in India has brought about the greening of formerly near-barren land. Water is now available in larger quantities and for longer periods than previously. Farmers can now grow more than one crop in this arid environment. Surplus harvests, better prices and accessible markets have led to improved living conditions of the village community. This success is reflected in the rate of adoption of similar approaches by neighbouring villages.

In Sudan, a community forestry project has achieved great success by controlling the encroaching sand-dunes that threatened the Ed Debba community by the banks of River Nile. Trees were planted to hold back sand that threatened farms, houses and infrastructure. Water availability has been improved. This has given a new hope to the people of Ed Debba, some of whom had lost their homes and fields to the moving sands. In a muslim country where economic activities are often dominated by men, the project has opened new opportunities for women, who are now involved in many projects such as the production of seedlings and the manufacture of energy-saving stoves. These new opportunities have given them a measure of financial freedom and confidence without disturbing established customs.

These case studies tell us that success in combating desertification is possible. But community participation is essential at all levels of the project's development. To fully participate, communities need to be empowered through the establishment of village-level decision-making structures and through credit facilities that are recognized and supported at the national level. Governments need to show their commitment to the bottom-up approach. Project design has to be based on the understanding that development cannot be achieved unless its participants are also its architects.

The Prairies, the drylands of Canada, were my home so I have a feel for their beauty, their strength and also their fragility if overused. I am therefore pleased to be able to salute successful efforts to save the drylands, especially here in Nairobi, our United Nations Headquarters. These awards provide recognition of the ability of dryland peoples to solve their own problems and work for environmentally sustainable development.

An extract from Ms. Elizabeth Dowdeswell's message delivered in Nairobi on 17 June 1996 to mark the World Day to Combat Desertification and Drought.

Climatic Fluctuations as a Source of Desertification in a Semi-arid Region of Argentina

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Introduction

The ecological and socio-economic consequences of rainfall fluctuations are well known, particularly when rainfall levels decrease. Decreased rainfall is likely to result in droughts, defined as a "natural recurrent hazard" by Kassas, Ahmad and Rozanov (1991). Droughts may start or accelerate desertification processes as happened with the prolonged drought in Africa that brought about catastrophic losses of agricultural land and livestock resources during 1968-1986.

But not only do droughts cause desertification. Increased rainfall may also start or accelerate desertification. This is the case in a semi-arid region in Argentina where positive fluc-tuations shifted the semi-arid/humid boundary westwards, bringing about over-cultivation of marginal farming lands. The area involved belongs to the Chaco region, covering part of Bolivia, Paraguay, Brazil and northern Argentina. In this article, we are particularly interested in West Chaco, Argentina owing to its semi-arid climate.

Rainfall variation over the last decades

Arid and semi-arid land makes up 75 per cent of Argentina.(Fig.1). The boundaries of these areas are delineated by annual precipitation (Roig et al., 1988): 700-800 mm separate semi-arid from humid areas and 250-300 mm divide arid from semi-arid zones. The northern part of the country, north of Bruniard's climatic limit (Bruniard, 1982), is under the influence of the Atlantic semi-permanent anticyclone with rains in spring and summer. To the south of this climatic limit, in contrast, rainfall occurs mainly in the cold season (Pacific anticyclone Fig.1).

Ever since the 1970s positive fluctuations of rainfall have been detected in the north of Argentina (Minetti and Sierra, 1984; Hoffmann, 1988). Figure 2 shows clearly this positive tendency in the 20th century for a meteorological station in the centre of the study area (Santiago del Estero province). As an ecological consequence of this positive trend, the semi-arid/humid boundary shifted westwards about 140 km on average (57-220 km) along the humid plain border, and the semi-arid/arid boundary also moved westwards about 88 km (40-170 km). Therefore, the arid diagonal of Argentina became narrower in the 1970s (when compared with the 1960s, see Fig.3). In the study area, the amount of rainfall increased about 27 per cent between 1931-1960 and 1971-1980; in some regions the increase was 33 per cent (Fig.4).

This temporary increase in water availability (Fig.5) encouraged people to deforest mainly for cultivation purposes. These marginal areas, which are risky for crop production (rainfed agriculture); may allow for quick economic gains now but they will be short-lived on account of the actual degradation of the ecosystem and

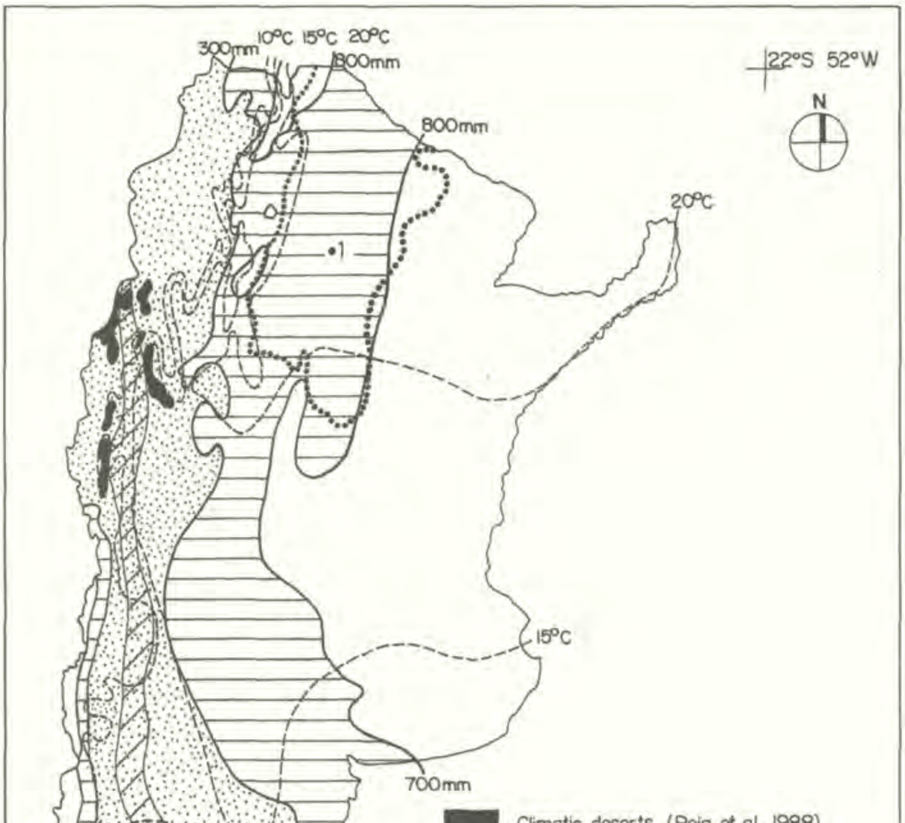

Figure 1. Location of climatic deserts (<50 mm/year), and arid (arid diagonal), semi-arid and humid zones of Argentina (from González Loyarte, 1995).

of the inevitable return to the usual rainfall levels.

Use of these lands in the recent past

The northern semi-arid area of Argentina is covered by Chacoan forests. At the turn of the century these forests played an important role in the economic development of Argentina, as reported by Ledesma & Ledesma (1983).

Since the last third of the 19th century, with the installation of the railway, exploitation of these forests increased. This happened because of the remarkable quality of the wood from the Chacoan trees. The most important trees being *Schinopsis balansae* and *S.lorentzii* ("quebracho colorado") owing to their wood elasticity, high density and durability all of which made them ideal for railway sleepers. Thus, "forest-mining" or intensive misuse of the forest began.

The exploitation was selective; first the larger and more beautiful trees, the *Schinopsis spp.* and *Aspidosperma quebracho blanco* were cut down, this was then followed by the smaller ones. Consequently, only old, diseased and misshapen trees remained, a sort of "negative forest selection". Smaller trees were used as fuelwood for steam locomotives and as charcoal. The regeneration of larger trees was prevented by the felling of young trees for poles. Under this constant pressure forest recovery was almost impossible. Once the forest was exhausted the big companies moved to other regions of virgin forest and resumed the over-exploitation cycle. And so the desertification process in the Chaco region began, a slow and insidious ecological degradation.

Once the degraded forest was abandoned the remaining vegetation was used for raising animals, cattle and later goats. The livestock degraded the vegetation and compacted the soil by overgrazing. The hunting of wild animals and birds (Ledesma & Ledesma, 1983) also took place and shrubs and trees - scrubland - took the place of the forest.

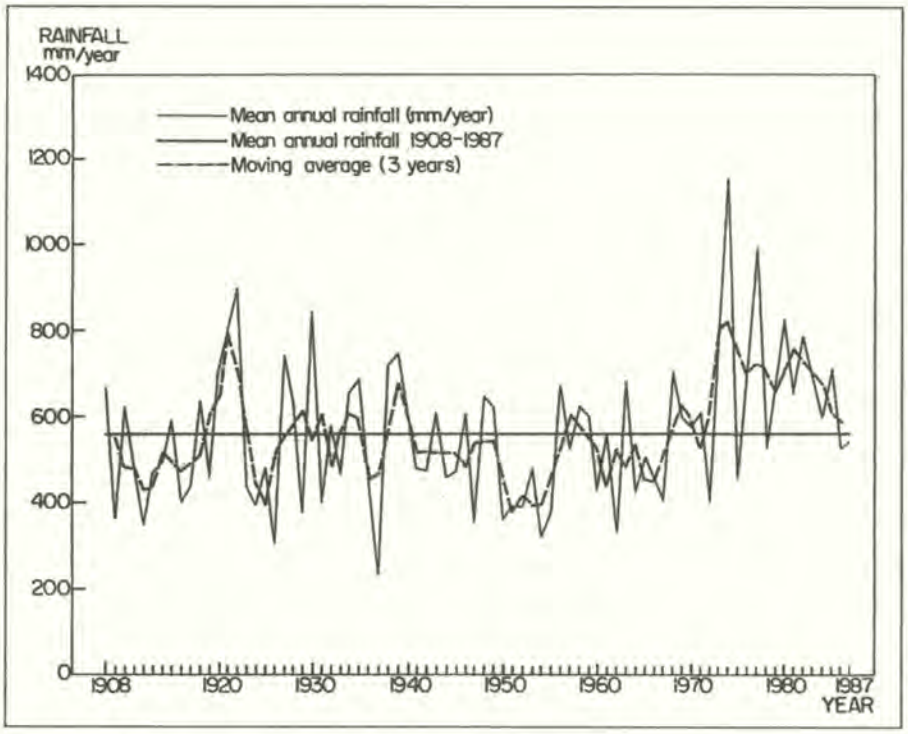

Figure 2. Evolution of mean annual rainfall at the Santiago del Estero station from 1908 to 1987 (Made with data from Bianchi & Yáñez, 1992).

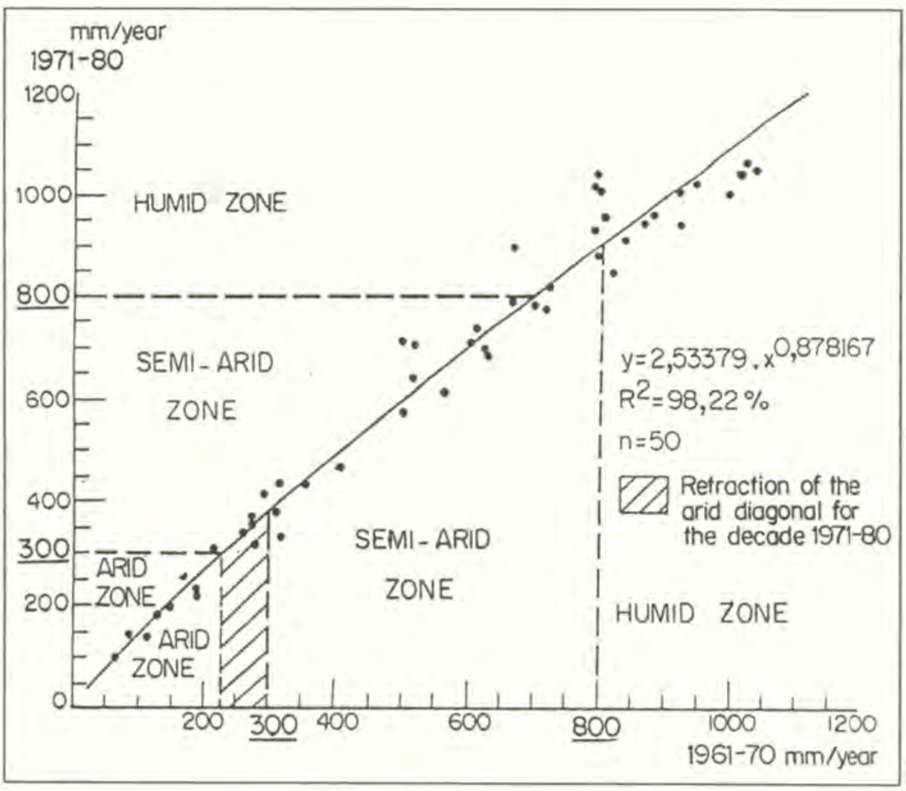

Figure 3. Mean annual rainfall regression between decades 1961-70 and 1971-80 for 50 meteorological stations under the influence of the Atlantic semi-permanent anticyclone (from González Loyarte, 1995).

What is going on now?

As a consequence of the positive fluctuation of rainfall during the 1970s the water balance became more favourable, and dry periods grew shorter (Fig.5). This change, combined with profitable grain prices and a growing interest in the agricultural development of the semi-arid region, encouraged people to deforest and practice rainfed agriculture.

An inquiry concerning the type of forest cleared was conducted among farmers (Casas et al., 1983a) in a central province of the semi-arid region of Chaco (Santiago del Estero). The results showed that most cleared areas were forests already degraded where the tree layer reached only 6m to 8m in height including *Schinopsis lorentzii*, *Aspidosperma quebracho-blanco* and *Prosopis spp*. The second layer, denser, 2m to 3m high, was composed of *Acacia praecox* ("garabato"), *Acacia aroma* ("tusca"), *Celtis tala* ("tala") and *Condalia microphylla* ("piquillín"). These forests were used as grazing lands with a carrying capacity of one animal to every five to 10 hectares. The remaining deforested areas varied from intensively exploited forests with fairly small trees to open spaces with shrubby grasslands. When these areas were cleared they already showed a certain degree of degradation: impoverished organic matter, low index of soil structure, compacted surfaces. Frequently lands subjected to clearing had already lost 30 per cent to 50 per cent of their organic matter (Casas et al., 1983b).

The soils concerned are mainly silt loam and silty clay loam, poor in organic matter and structure and therefore prone to water erosion and crust formation. These soils usually have a deep soil profile. Their water field capacity is medium.

Even though the majority of the areas surveyed were deforested for crop production and livestock rearing, during the first five years farmers would grow crops to make a quick profit and thereby recover their investment. Heavy machinery (150-200 HP) was used for clearing. When the forest products are extracted, the remaining worthless vegetation is often accumulated in rows for cultivation purposes. The livestock

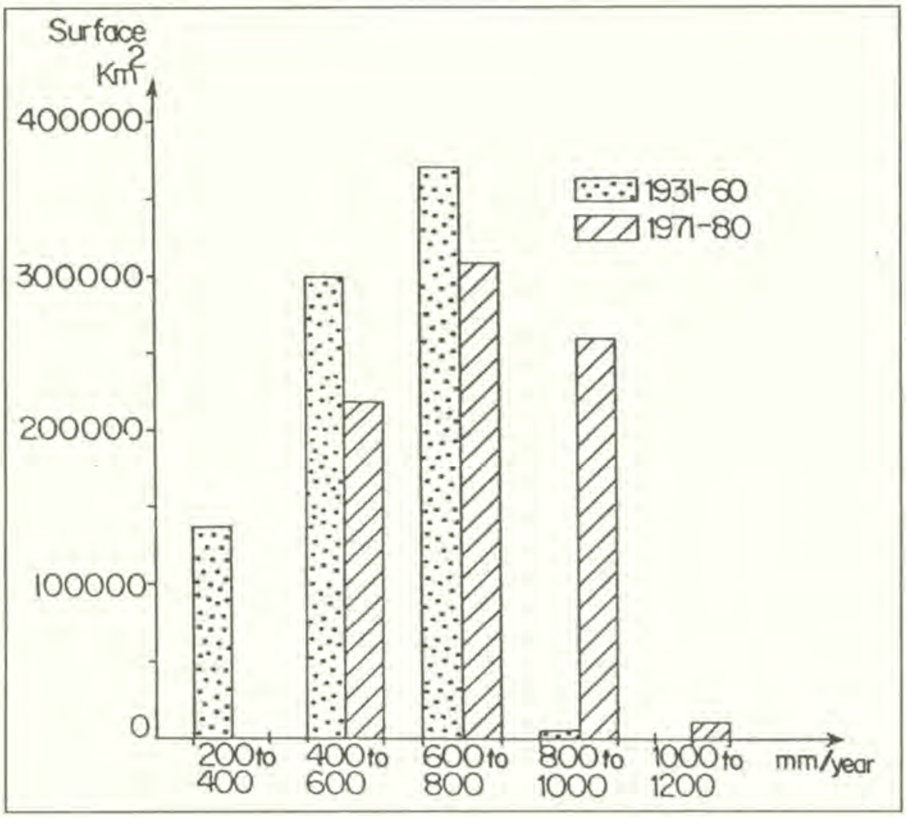

Figure 4. Variation in mean annual rainfall (mm/year) and affected surfaces (Km^2) for the periods 1931-60 and 1971-80 in the northern semi-arid region of Argentina (from González Loyarte, 1995).

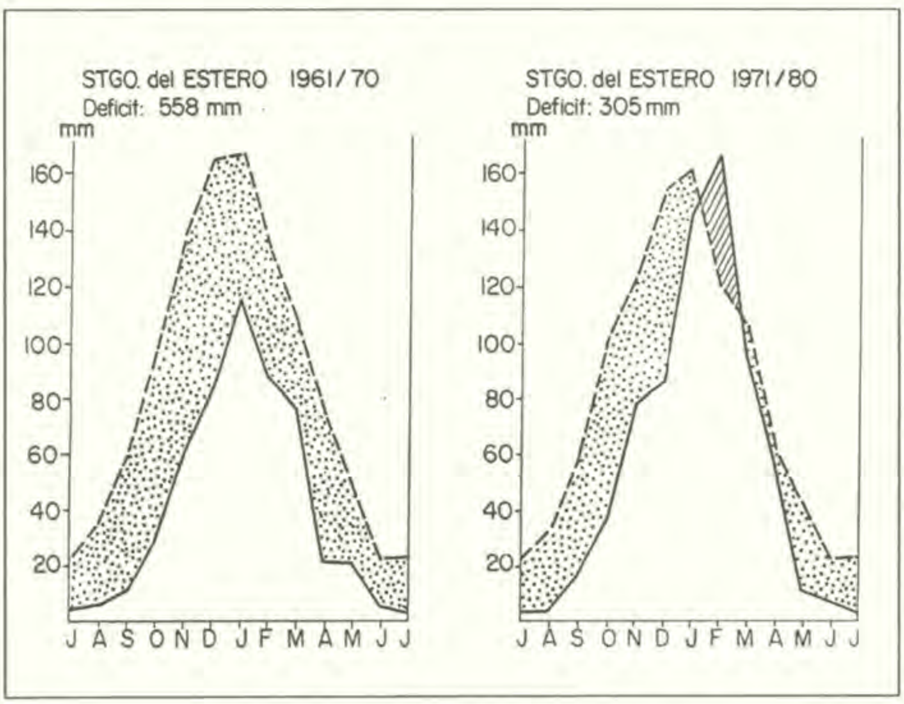

Figure 5. Variation in mean annual rainfall (___) and potential evapotranspiration (- - -) between decades 1961-70 and 1971-80 for a semi-arid region in Argentina (Santiago del Estero). Dotted areas: deficit; lined areas: excess (from González Loyarte, 1995).

feeds on sorghum, maize, Melilotus, winter grass, natural grassland (*Trichloris spp., Setaria spp.*), and native shrubs. The main crops are: sorghum, soya bean, dry bean, maize and sunflower (Casas et al., 1983b).

The evolution of cultivated, deforested and abandoned areas in the last two decades for three provinces of the semi-arid Chaco is shown in Figure 6. About 461,330 ha were estimated to have been deforested in Santiago del Estero, Salta y Tucumán from 1976 to 1984. During the 1980s (1984-1989) nearly 45,880 ha/year of land cultivated with these main crops was abandoned. It is uncertain whether the land was under permanent cultivation or whether the farmers practised a form of rotational cropping. Nevertheless, what is really important is that a number of deforested areas were not cultivated for one or more growing seasons. This is of relevance because natural vegetation and weeds invaded the abandoned lands. The ecological consequences of such alternate land use (deforestation - cultivation - abandonment - cultivation) are likely to be serious.

Ecological consequences of deforestation and cultivation

Casas *et al.* (1983b) evaluated the degradation processes in deforested lands after cultivation, their research centered mainly on the Santiago del Estero Province. The degradation processes are: a decrease in organic matter, in nitrogen and in the index of soil structure (ISS); and an increase in apparent soil density (ASD)(Fig.7). Reductions of organic matter for different soils average 4.4 per cent after five years of cultivation, 2 per cent after 5 to 10 years and 2.6 per cent after 10 to 15 years. According to an FAO soil assessment criteria (FAO, 1980), the first five years of cultivation fluctuate between a high to very high rate of degradation of organic matter. During the process of cultivation, soils become compacted. This can be evaluated through the apparent soil density which increased from 1.1 g/cm^3 to 1.25-1.5 g/cm^3 (16-36

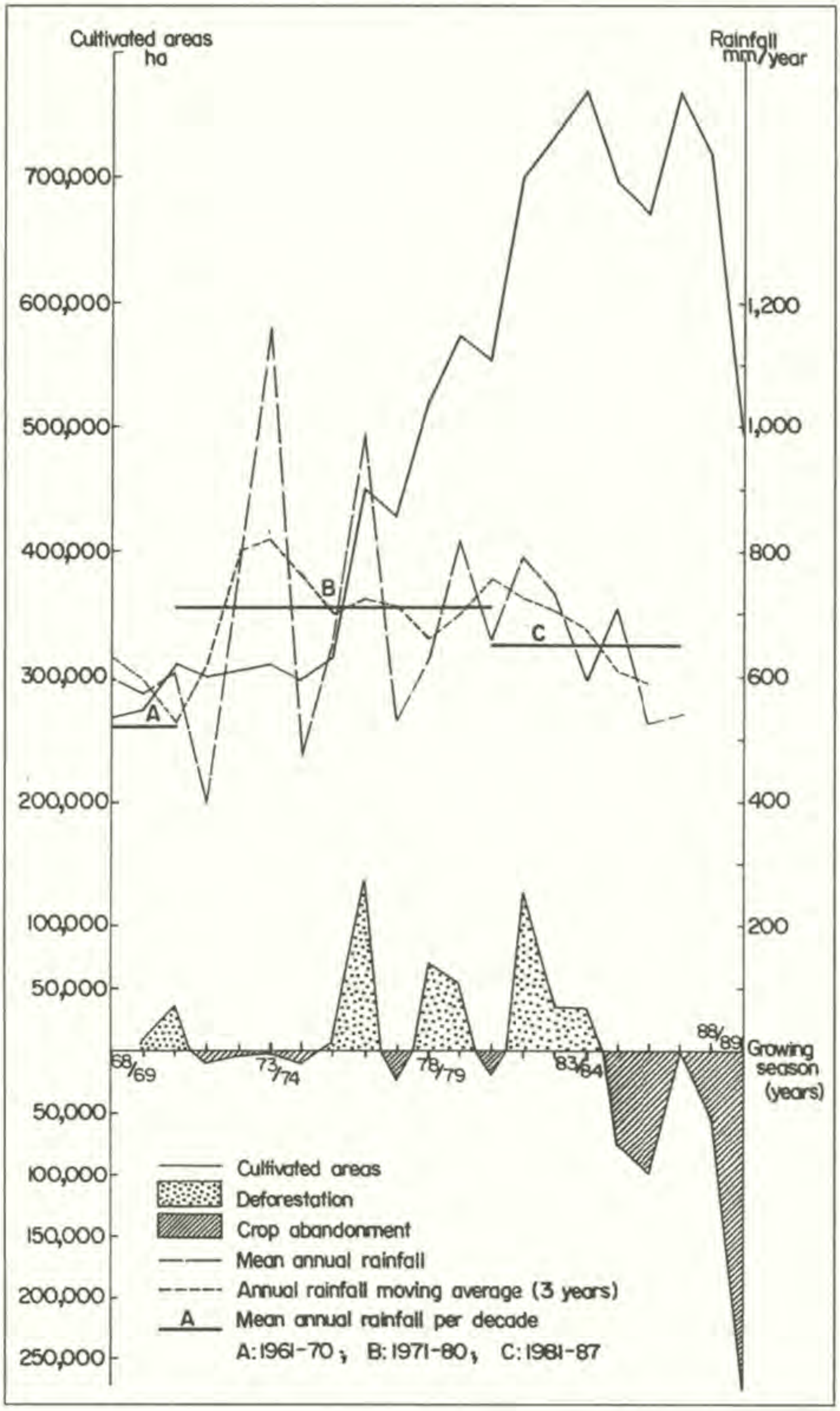

Figure 6. Evolution of areas subjected to rainfed agriculture, deforestation and abandonment in three provinces of semi-arid Chaco (Santiago del Estero, Salta y Tucumán), Argentina.

per cent increase) during the first five years with an additional increase of 27 to 32 per cent in the subsequent 10 years of land use (a total of 50 to 73 per cent of soil density increase in 15 years of cultivation). The ISS was reduced by 34 per cent for the best structured soils, and by 17 per cent for less structured soils during the first five years to reach, after 15 years, a total ISS reduction of 30-40 per cent. It is clear that the most important degradation occurs during the first five years of cultivation. Unfortunately, this is also the period when most farmers cultivate deforested lands (before starting range management).

In addition to the soil evaluation, Casas *et al.* (1983b) also conducted an inquiry among farmers to analyse the main processes of natural resource degradation. The results obtained were as follows:

Soil encrusting	30%
Patches	23%
Water erosion	18%
Decreased yield	12%
Wind erosion	10%
Increased density of arable layer	7%

Soil encrusting: a widespread problem, is the consequence of loss of organic matter, a deficient structural index and high loam content in soils.

Patches: areas where crops grow irregularly as a result of land clearance (i.e. the areas where worthless deforested material is accumulated in rows and then burnt). This results in a slight soil alkalinization and salinization with an increase in contents of potassium (K) and magnesium (Mg). There is also a substantial increase in calcium carbonate ($CaCO_3$) coming from the subsoil layers when trees and shrubs are uprooted. A lower water holding capacity of the soil and crop chlorosis was detected in these patches.

Water erosion: the combination of long gentle slopes with crops requiring periodic weeding (soya bean, maize, sunflower) determines water erosion processes of every kind (sheet, rill, and gully erosion). This problem is exacerbated in undulating lands with 1 to 4 per cent slopes or even steeper (up to 16 per cent). In the latter case gully erosion occurs.

All of the above-mentioned degradation processes are on-site desertification impacts. In this respect, two definitions are worth mentioning, one adopted by UNEP in Nairobi, in

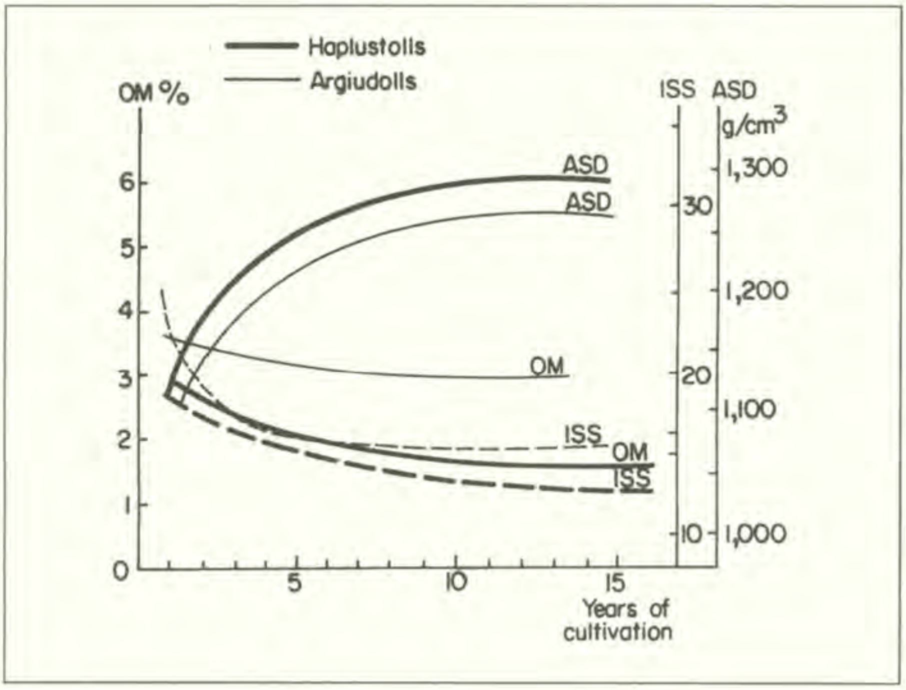

Fig.7. Evolution of organic matter (O.M.), index of soil structure (I.S.S.) and apparent soil density (A.S.D.) under cultivation in two types of soil in a semi-arid region in Argentina (Santiago del Estero). Adapted from Casas et al.,1983b.

February 1990: *"Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse human impact"* (Kassas *et al.*,1991) and the last definition issued by the United Nations Conference on Environment and Development (UNCED) in Río de Janeiro, in June 1992:*"Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities"*.

The effects of desertification in the semi-arid Chaco mainly relate to changes in plant growth (reduction of: primary productivity, biomass and genetic materials), animal life (reduction of wild animal populations and degradation of livestock), and soil status (loss of organic matter, compaction and crust formation, soil erosion, salinization, etc.).

These changes are causing modifications to the microclimate as reported by Ledesma & Ledesma (1983) associated with plant cover impoverishment. Air temperature is higher in degraded fo-rests than in nearby virgin forests and in forests on their way to recovery; temperature ranges are also wider in a degraded forest. Consequently, there is an increase in evapotranspiration and a decrease in relative air humidity in degraded forests. Therefore, degradation entails a dryer and more fragile ecosystem.

What can be done? Some comments for the future

Different researchers have pointed out that these semi-arid Chacoan lands are marginal as regards cultivation. Some researchers consider it necessary that the forest is kept free of livestock while others think that management should combine forest exploitation with range management. In the case of range management, rotational grazing is highly advisable, as shown in Figures 8A and 8B (adapted from Casas *et al.*, 1983b). These figures show that organic matter, nitrogen and the index of soil structure are higher under rotational grazing.

On the other hand, some researchers suggest that crops should be grown only during the good years, otherwise the risk to rainfed cultivation would be very high. But a prolonged period of rainy years may also be risky. In such periods farmers tend to overcrop the land which results in intense soil degradation. Thus, recovery of physical and chemical land fertility by means of grasslands becomes much harder (Casas *et al.*, 1983b). For haplustolls the cultivation period should not exceed one to four years (according to the soil series), and for argiustolls rotation should not exceed four to five years.

If these positive rainfall fluctuations were to persist in the following years,

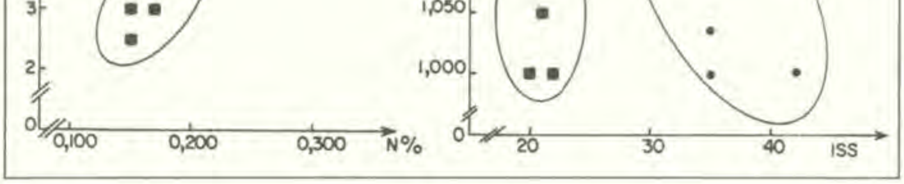

Fig.8. Variation in organic matter (O.M.) vs. nitrogen (N) (A), and apparent soil density (A.S.D.) vs. index of soil structure (I.S.S.) (B) under "forest" range management (continuous and rotational) for a semi-arid region in Argentina, Stgo. del Estero. (Adapted from Casas et al., 1983b).

cleared lands would continue to be used mainly for cultivation which would result in increased degradation. Pauperism would also be higher in the long run. Research shows that in the semi-arid Chaco over 30 per cent of people cannot meet their basic needs (INDEC-CEPA, 1994).

A quick and strong policy of sustainable development should be adopted to prevent desertification. According to Casas (1994) a good combination of grazing and agricultural activities in these semi-arid lands would produce a slight to moderate degradation. Finally, the most important conservation practice seems to be the management of forests involving both wood cutting and livestock grazing. For grazing purposes the elimination of some shrubs - some kind of selective clearing- as well as the use of natural grasslands appears to be the most appropriate procedure.

Therefore, policy makers should be advised by researchers about the impacts on ecology, economy and society due to mismanagement of marginal areas during wet periods. A long succession of wet periods might lead people to mistakenly believe that their region is immune to the vagaries of climate, when the reverse is the case and these periods may actually be starting a desertification process. Policy makers should become aware of desertification as a process of ecological degradation of dryland ecosystems that is slow and insidious with long-term effects on their people, economy and ecology.

Acknowledgements

To Prof. Nélida Horak for correcting the English text and Prof. Cecilia Scoones for the line drawings.

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The Potential Impact of Global Climate Change on Soils and its Salinization Effect on Food Production, Biodiversity and Irrigation Practices

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Climate change and soil salinity

One of the most topical and popular problems relating to man-made environmental change is global climate change and its influence on the environment, man, future food production and natural resources. For more than a decade this question has been the focus of general interest, as well as the subject of a great number of international projects, conferences and publications *(Our Common Future 1987)*.

Photo 1: Profile of salt-affected soil

The problem is general because worldwide climatic change, largely due to the intensive emission of carbon dioxide and other gases and the consequent change of temperature and humidity, would have an unpredictable but substantial effect on our globe particularly to the biosphere and mankind.

Global climate change would have a substantial influence on different elements of the biosphere including the soil. This question is discussed in the following books: *Global Soil Change* edited by Arnold, Szabolcs and Targulian (1990) and *Soils on a Warmer Earth* by Scharpenseel, Schomaker and Ayoub (1990), which summarize our present knowledge of the problem.

In spite of the large body of information on the general effects of climatic change on different soils, their productivity and environmental situation, we are still lacking sufficient data and concrete facts on the influence of this change on the various site-specific soil forming processes, i.e. the facts we shall be confronted with in the foreseeable future and which threaten our food production and the environmental functions of our soils. Such data would enable us not only to predict the expectable adverse processes but to take the necessary steps to prevent the tragic consequences which may ensue.

This applies to soils in general—because practically all of them are exposed to climatic changes which, to different degrees, influence their properties and productivity—and to salt-affected soils in particular.

"Salt-affected" defines the class of soils where the occurrence, quality, quantity and migration of water-soluble salts are the dominant factors of soil forming, as well as of the physical, chemical and biological soil properties. Salt accumulation in a soil limits the development of plant species, animals, microorganisms, i.e. of the entire biota. With the increase of salinity the biodiversity of soil habitats decreases and native species may disappear. Different types of salinization and alkalinization influence differently the biota and biodiversity of soils (Szabolcs 1989, 1991).

The potential salinity of soils not only diminishes the ecological potential of the given area but often entirely prevents agricultural production. Besides, drinking water for animals and humans may also be salinized and a toxicity of herbs and other native plants may develop.

The necessary alterations in urbanization, road and canal construction following the advent of climate change will indirectly influence the salinity and/or alkalinity of soils.

Desertification and salinization are associated not only with non-cultivated areas but also with human factors such as, improper policies and land use, overloading of the environment and a neglect of conservation. It means that besides natural factors, socioeconomic causes also contribute to the extension of both processes.

All the above facts and considerations lead to the conclusion that the study of, as well as the actions against, either desertification or salinization should be conducted jointly and reciprocally because salinization and desertification are often closely related:

(1) Salinization promoting desertification;
(2) Salinization developing concurrently with desertification;
(3) Salinization induced by desertification;
(4) Salinization strengthened by desertification.

In Figure 1 some of the interrelations between desertification and salinization are presented. It can be seen from Figure 1 that during salinization and desertification some attributes of the other process appear. e.g. desertification, as a rule, provokes salt accumulation which is one of the characteristics of saline soils. On the other hand salinization causes a thinning of plant cover on the soil surface which is, in this case, one of the attributes of desertification. Such correlations clearly demonstrate the interrelationship between the two processes. During desertification, partly as a result of introducing irrigation, and partly as a result of the degradation of biota, secondary salt accumulation often occurs (Kovda 1980, Szabolcs, 1992).

From the above it will be obvious that any change in climate has a fundamental influence on the formation and migration of water-soluble salts as well as on the processes of soil salinization, alkalinization or desalinization and dealkalinization. This applies to both direct and indirect climatic influences on soil forming processes.

In general these effects can be divided into two groups:

(a) Direct influence, through changing the mean annual temperature and mean annual precipitation;
(b) Indirect influence, through the changes in lithosphere, hydrosphere, biosphere and atmosphere.

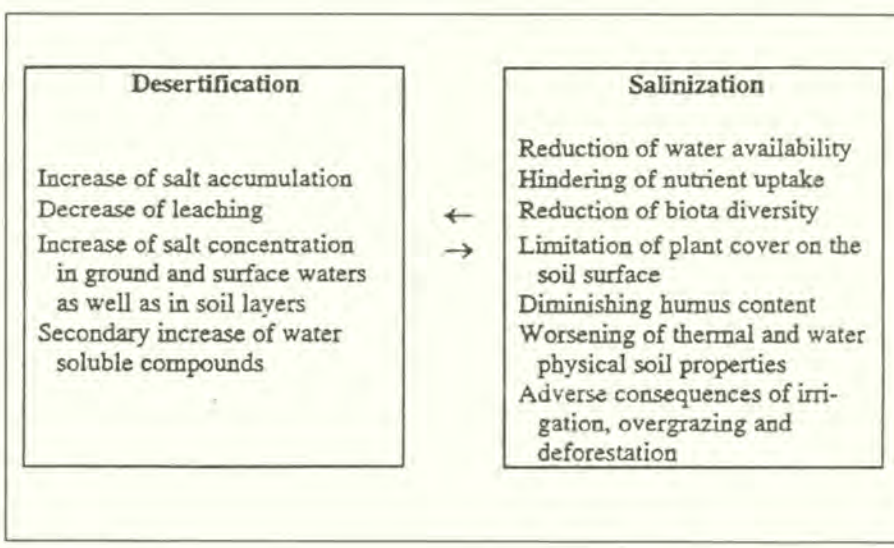

Figure 1. Interrelations between the attributes and consequences of desertification and salinization

Figure 2
INFLUENCE OF CLIMATE CHANGE ON SOIL SALINIZATION AND ALKALINIZATION

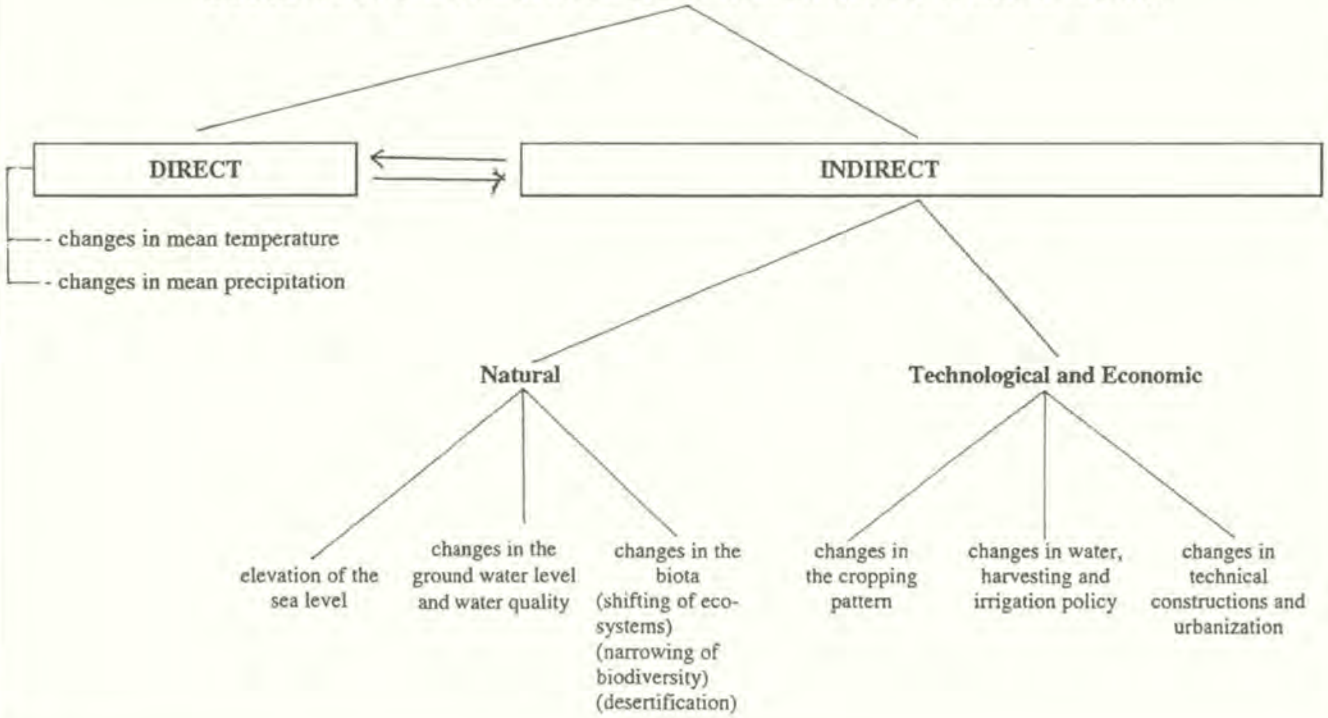

Figure 2. Influence of climate change on soil salinization and alkalinization

In Figure 2 a scheme of the potential influence of climate change on soil salinization and alkalinization is presented.

However, there are questions which need urgent answers. For instance, how will salinity conditions be directly affected by rising temperature and changes of precipitation, and indirectly, by the elevation of the sea level?

There are also other suggested indirect effects of climatic change, i.e. the shifting of the wheat and corn belts and other cropping patterns towards the north in the northern hemisphere. However, these opinions are based on rather rough assumptions rather than on data underlain by measurements and calculations.

Admittedly, it is very difficult, sometimes impossible, to give exact figures on the possible effects of climate change and its implications for and impacts on soil properties. Still it is necessary to elaborate up-to-date methods, models and scenarios as has been attempted by several authors (Rotmans - Huhne - Downing 1994, Szabolcs - Rédly 1989) in an effort to prepare ourselves for whatever the future has in store.

As these papers deal mainly with European conditions, their conclusions are far from being sufficient for characterizing the anthropogenic processes of salinization and alkalinization all over the world however methodically they might be adapted for other continents.

Main aspects of and scenarios for the potential impact of global climate change on soil salinization and alkalinization

In Figure 3 the geographical position of the three scenarios and the dominant impacts of supposed climate change are indicated.

I. Scenario for direct impact

Direct impact means the influence of climatic change on the soil forming processes through changes in temperature and precipitation.

This scenario depicts the potential changes in soil salinity caused by the alteration of climate for the European shores of the western basin of the Mediterranean (see Fig. 4). In this region, salt-affected soils can be found mainly in the Iberian Peninsula and, to a smaller extent, in the south of France, in Italy, Sicily, Sardinia and Corsica, as well as on the Dalmatian coast of the Balkan Peninsula. The total area dealt with in this scenario is 1,979,959 square kilometres including a land surface of 885,826 square kilometres.

On the basis of the available meteorological predictions and scenarios (Rotmans - Huhne -Downing 1994) we assumed that due to the possible climatic changes resulting from the accumulation

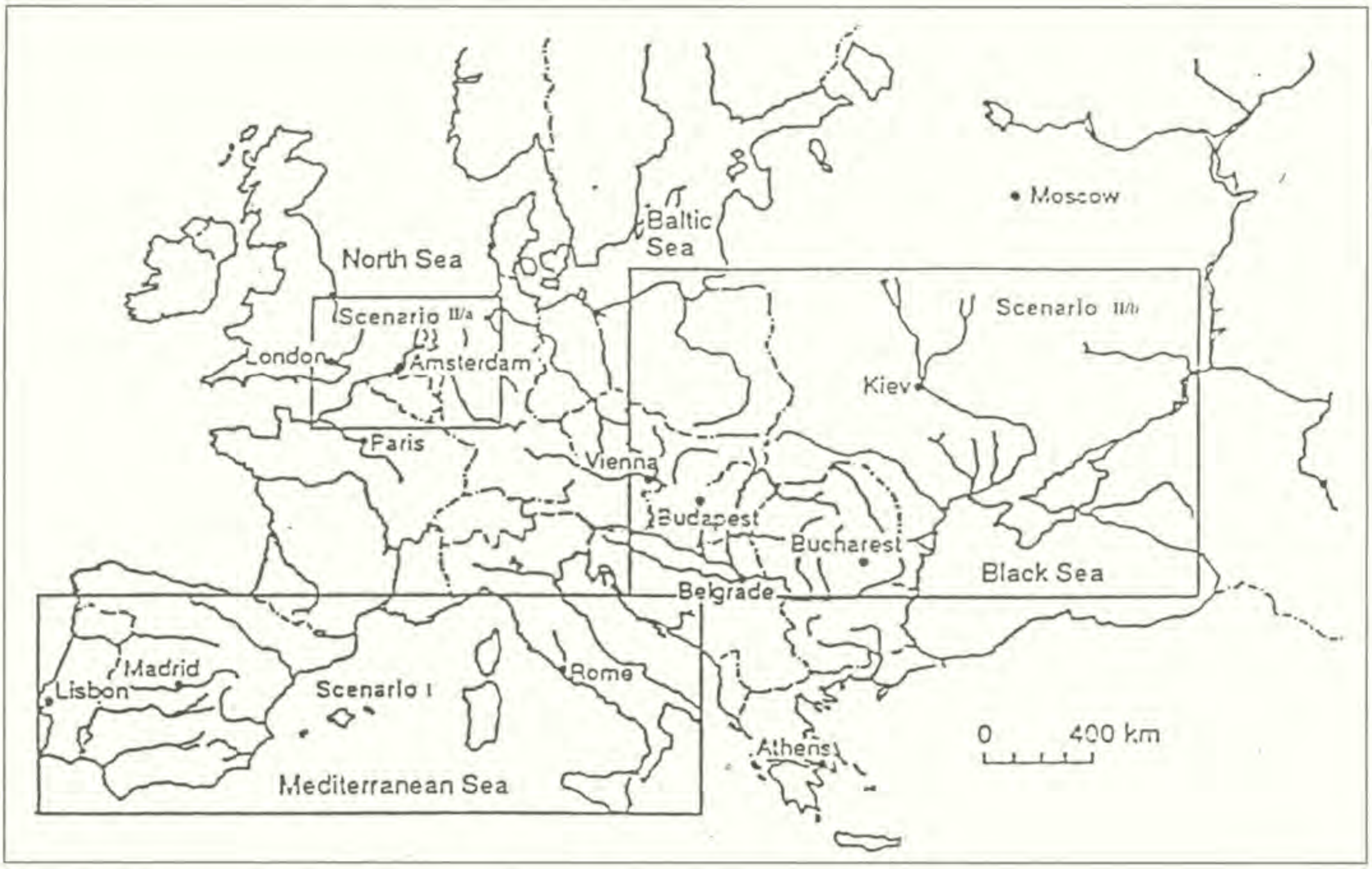

Figure 3. Position of the scenarios in Europe

of CO_2 and other causes, the average annual temperature of the territory will increase by about 1°C over the next 50 to 70 years. Consequently, the aridity index will also go up, creating progressive salinity in the marginal territories where, for the time being, salinity does not exist or can be found only in latent form in the ground or in waters. The following assumptions were made:

In Figure 4 the territory of salt-affected and potentially salt-affected soils—the latter a consequence of climatic change—are represented.

It can be seen that the territory of potential salinity substantially surpasses that of existing salinity in all affected areas. The salt-affected soils covered by the scenario total 56,168 square kilometres (6.34 per cent of the land surface), which is twice as large as the area affected by salinity at present. The dry regions of the Iberian Peninsula (such as Castilia, the Ebro Valley, Southwestern France) and several areas in the Italian and Balkan Peninsulas where aridity is on the increase, are particularly exposed to the danger of salinity.

It must be noted that if the increase in the average annual temperature surpasses 1°C, the increase in salinity will not be linear, but exponential compared with the growth shown in Figure 4.

As salinity threatens very fertile agricultural lands in the mentioned territories it must be predicted well in advance so that preventive measures can be elaborated before the climatic change occur. It is to be remarked that, in the scenario, potential salinity equally endangers river valleys and estuaries (Ebro, Neretva, Rhône, Guadalquivir, Tajo, etc.) as well as plains and plateaux (Castilia, Aragonia, UvAbria).

II. Scenarios for indirect effects

A. Sea level elevation

Apart from the direct effects of the changes in temperature and precipitation, many-sided and diverse impacts result from the indirect effects of climatic change on soil salinity and/or alkalinity. Such indirect effects can be divided into so-called natural and technological groups. In Figure 2 a schematic delineation of this phenomenon was given.

Natural impacts include soil salinization caused by an elevation in sea level on the shores and adjoining territories, salinization of soil profile as a result of rising saline ground water level, and salt accumulation in the top layer of soils as a consequence of the change of biota, particularly the alteration of native plant cover. Each of these processes and many others, occurring and developing in the wake of climatic changes, influence to a varying extent the balance and migration of salts in soils.

The process of desertification associated with the extension of salt-affected soils also belongs to this subject.

From the possible impacts, which we named "indirect natural" effects, we studied potential salinity caused by sea level elevation.

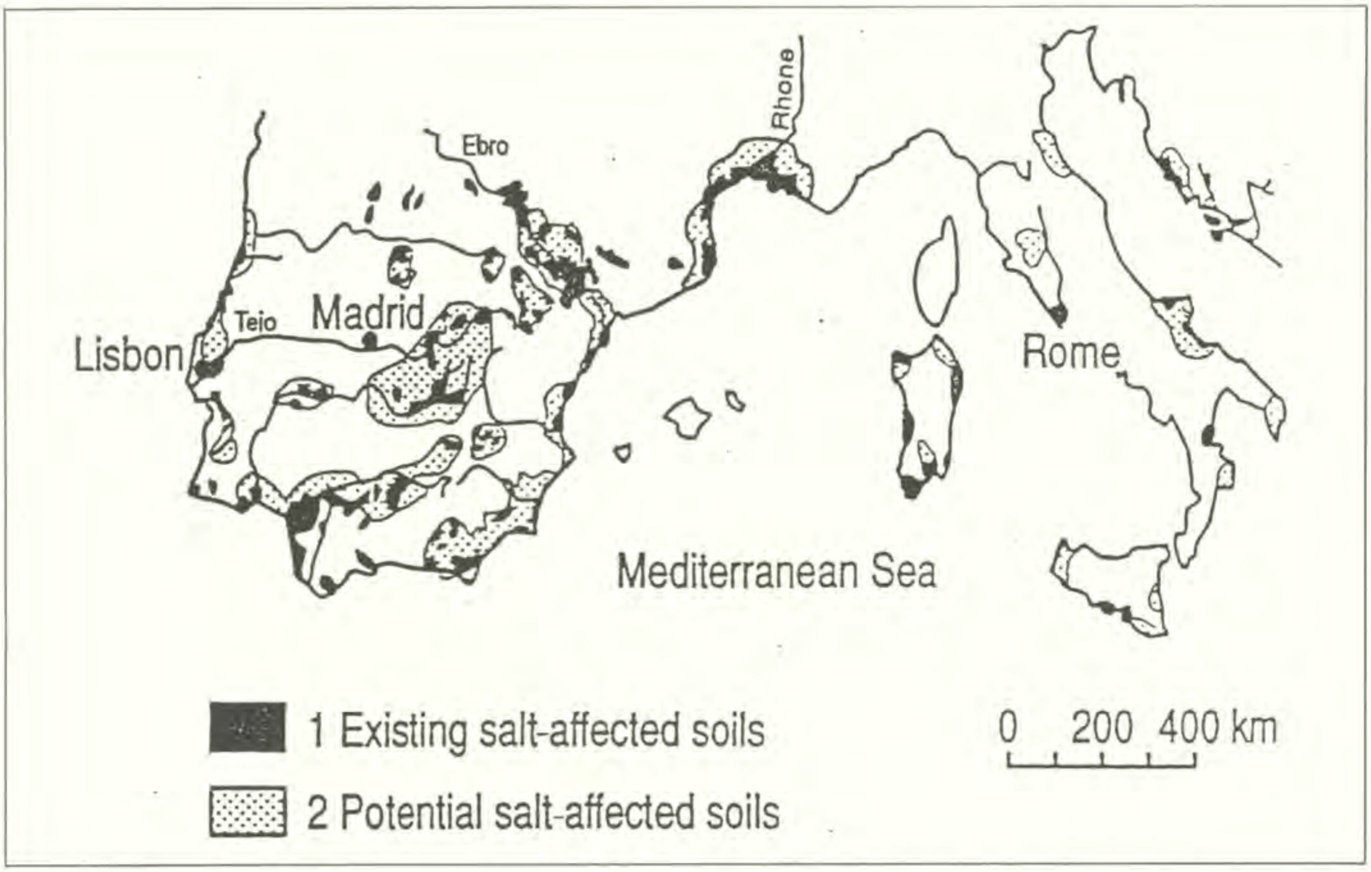

Figure 4. Salt-affected soils and potentially salt-affected soils as a consequence of climatic change on the European shores of the western basin of the Mediterranean

Scenario A. covers a part of North-western Europe (see Fig. 5) rendered eminently suitable for the purposes of this study by the following properties:

(a) Measurable extension of salt affected soils,;
(b) Good probability of sea level elevation as a result of global climatic changes in the next 50 years.

The total territory covered by this scenario is 344,942 square kilometres

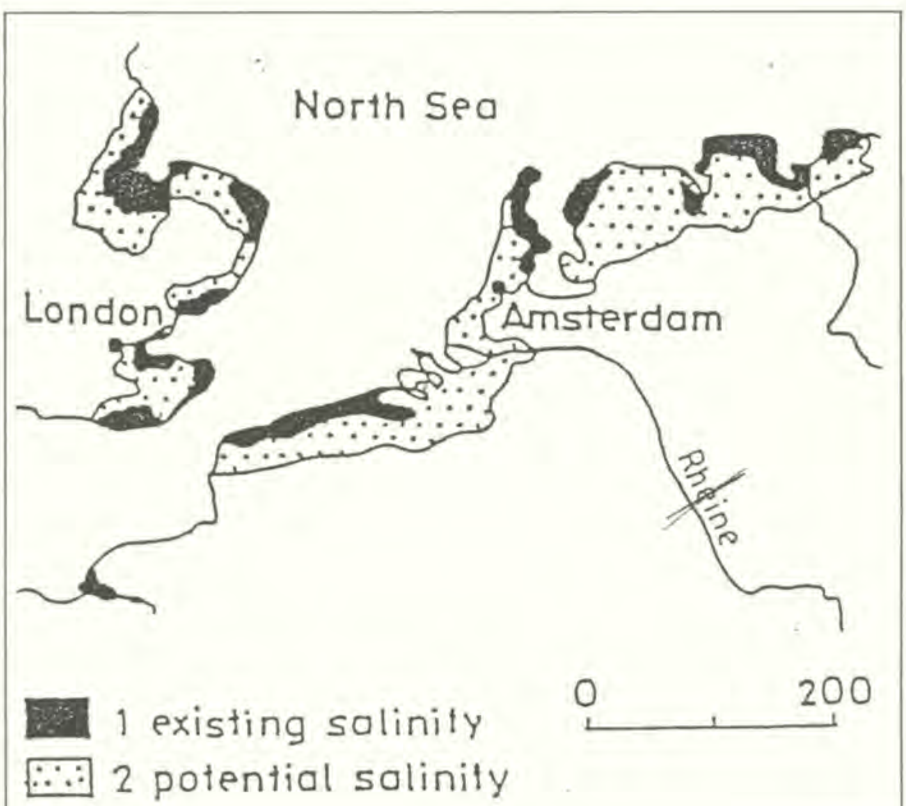

Figure 5. Salt-affected soils and potential salinity as a consequence of supposed sea level elevation in North-western Europe

with 226,393 square kilometres land surface, including the south-eastern part of England, the western part of The Netherlands, Belgium, and the north-eastern part of France bordered by the North Sea, the Atlantic Ocean and the English Channel. The scenario deals mainly with coastal saline soils of high sodium chloride content on several seashores and adjoining areas.

The territory of existing and potential salinity discussed in Scenario A. is presented in Figure 5.

As can be seen in Figure 5, the territory of potential soil salinity caused by sea level elevation substantially surpasses that of existing salinity. Actually potential salinity is a such greater hazard all over Europe than existing salinity.

It is one of the first observations in the scenario that potential salinity is to be expected in the lands lying around existing salt-affected soils.

It should also be noted that if sea level elevation surpasses the values taken for granted in this study, the extension of potential salinity will not be linear, but will increase to an even higher degree.

There are many seashores where,, in the wake of climatic change, soils may become salinized to a much greater extent than foreseen in our scenario (Gulf of Bengal, Gulf of Guinea, South-east India, etc.) and for which the preparation of similar predictions and scenarios would also be possible and favourable.

Changes in water harvesting and irrigation policy

The technological and economic consequences of climatic change influencing soil salinization and/or alkalinization will inevitably include measures aimed at sustaining food production and its reasonable economic status in the given territory. changing cropping patterns and shifting crop belts will be among them. Changes in water harvesting and irrigation policy will also be indispensable after the change of climate in many regions of the world. For instance, as the climate of some rainfed agricultural regions turns drier, the collection of precipitation water and the construction of reservoirs will be necessary. As another consequence of the above process, irrigation will have to be extended to areas which need not have been irrigated before the decline in natural precipitation.

It is essential to stress the importance of thorough studies and reliable predictions as well as models for the characterization of such multiple effects in different places taking into account not only natural but also local economic and political circumstances. Unfortunately apart from rhetorical rubrics, only a few predictions and scenarios are available, and even fewer contain numerical values.

We prepared scenario B which predicts soil salinization as a possible consequence of extending irrigation and changing cropping patterns in the continental part of Europe, should climatic changes ensue.

It was assumed that irrigation will have to be extended to maintain the level of agricultural production.

For the scenario, we selected a part of Europe (see Fig. 6) where, as a result of both climatic and economic conditions, irrigation has been practiced for a long time. More than half of all irrigated areas in Europe are situated in the territory covered by the scenario.

Salt-affected soils are extensive in the countries of scenario B. A great part of then is situated in the vicinity of irrigation systems or within the territories they serve.

In nearly all countries covered by the scenario the further extension of irrigation should be envisaged. In countries where precipitation is low (e.g. Russia, Ukraine, Moldavia, Bulgaria, Remania), the increase planned will be greater than in those lands which have not suffered recently from aridity (Austria).

At present the ratio of irrigated soils is lower than 20 per cent in the countries of the scenario; in most cases it is below 10 per cent of the total agricultural land. The envisaged increase in irrigated areas varies from country to country, but in no case is it more than 100 per cent for the next 50 to 60 years. One of the main limiting factors of the extension of irrigation is the shortage of good quality irrigation water in most of the counries concerned.

Taking into consideration the circumstances described above, we assumed in scenario B that up to the middle of the 21st century the irrigated territories will at most double and made calculations accordingly.

There are two main processes of salinization caused by irrigation:

(1) Salt accumulation in soil layers from the salt content of irrigation water; and
(2) Salt accumulation in soil layers from the salt content of rising ground water.

As regards soil salinization from irrigation water there are acceptable regulations for the quality control of irrigation water in the countries of the scenario. Consequently, only a small part of the secondary salinization processes develops at present as a result of poor quality irrigation water. In the case of soil salinization by ground water, even under current conditions the table of salty ground water (which sharply rises in most irrigated areas following an increase in aridity) causes increased salinity in the soils. This process can be seen to be one of the most threatening for the future.

Considering climatic, physics-geographic, hydrological agricultural and pedological aspects, we have elaborated a map to demonstrate the hazards of soil salinity for the territory of the scenario. The following assumptions were made:

(1) Irrigated areas will increase up to 2050 until a maximum of twice the current area is reached;
(2) There will be changes in climate according to meteorological predictions, but no elementary disaster will occur;
(3) Quality requirements for applied irrigation water will remain in force;
(4) River beds and major hydrological constructions will remain as they are.

Figure 6 demonstrates the extent of existing and potential soil salinity in the area of scenario B under the above conditions.

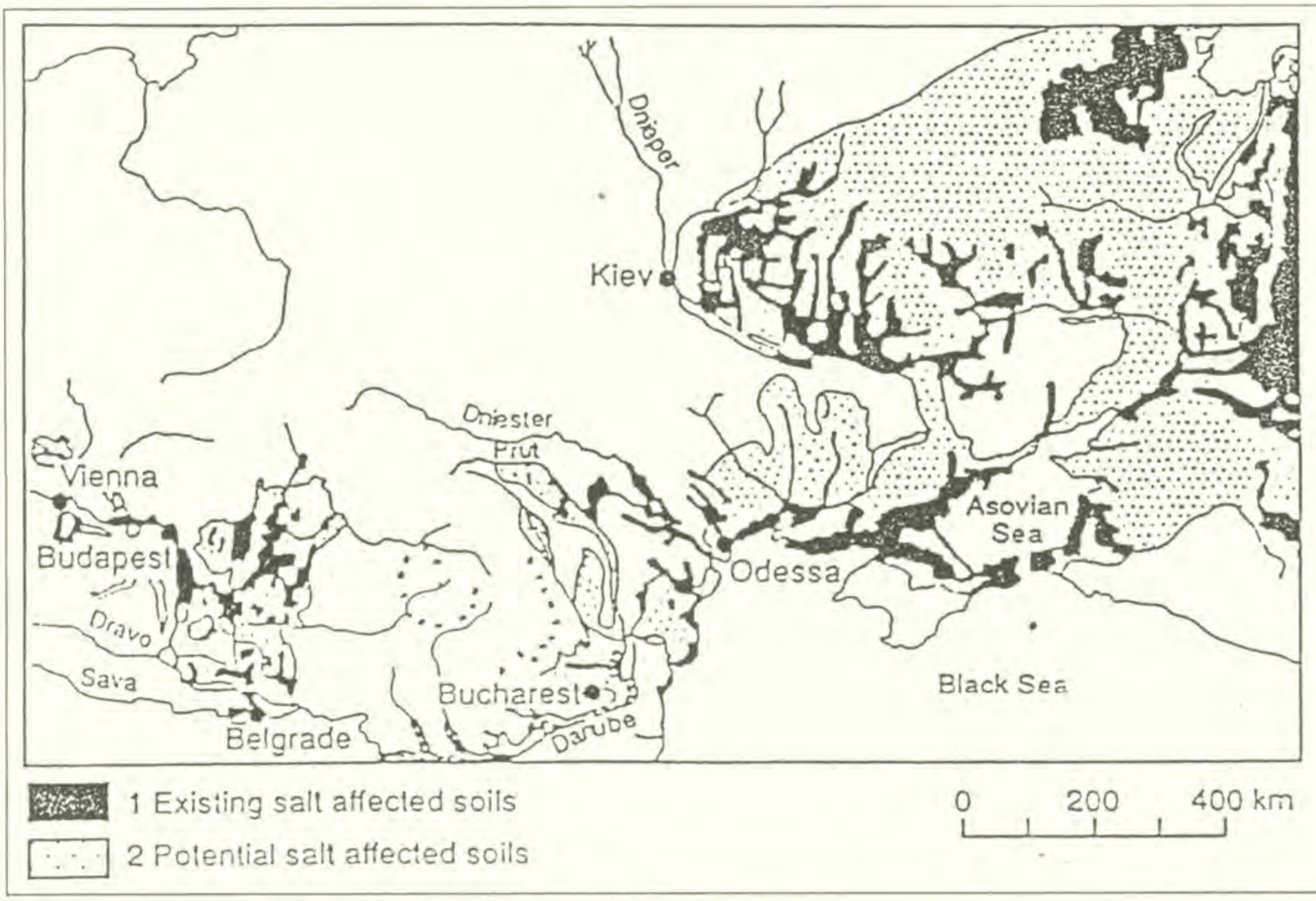

Figure 6. Salt-affected soils and potential soil salinity and alkalinity as a consequence of extended irrigation in Central and Eastern Europe

The territory indicated in Figure 6 is about 20 per cent of the total land area of Europe and represents different areas intensively affected by both present and potential salinization, including Romania, Hungary, Austria, Yugoslavia, the Czech Republic, Slovakia, Croatia, Ukraine, Moldavia and large areas of the European part of Russia.

Although the scenario includes only about 20 per cent of the land area of Europe, about 50 per cent of all the soils, salt-affected at present on the continent, can be found here.

As can be seen from Figure 6, the territory of potential soil salinity in scenario B exceeds that of existing salinization and is nearly twice as large.

The figures are as follows:

	Square kilometres	
-	Total territory of Scenario B (without the surface of the Black and Azovian Seas)	2,1079,840
-	Territory of existing salinization	218,383
-	Territory of potential salinization	418,047

It is also clear from this nap that potential salinity may develop around the soils which are at present salt-affected and may threaten fertile areas not yet affected by this phenomenon. It can also be seen that, in practically all the areas where salt-affected soils occur at present, the hazard of further salinization exists. The valleys of the Danube, Prut, Dnieper, and Volga rivers as well as most lowlands of the region are especially endangered. In territories where salt-affected soils can be found in smaller or larger spots as a consequence of secondary salinization caused by irrigation, vast, continuous stretches of land will be covered by saline and alkali soils. Evidently, potential salinity also exists in large areas where salt-affected soils are not presently found.

Prognoses and prevention of secondary salinization and alkalinization

As it is very difficult and expensive to reclaim soils affected by secondary salinization and/or alkalinization the prevention of such processes is highly desirable.

Theoretical and technical activities relating to the hazards of secondary salinization and alkalinization must be intensified. Up to now the influence of expectable geochemical and hydrogeochemical processes have been underestimated in many places which, sooner or later, will result in salt accumulation through irrigation in the given territory. While an abundance of studies and quality requirements for irrigation water is available (Szabolcs - Darab 1982) the effect of ground water on soil salinity is often forgotten.

A comprehensive preliminary study of not only soils and surface waters, but also of underground waters and layers is necessary before extending existing irrigation systems or planning new ones (Darab - Ferencz 1969, Darab-Rédly-Coillag 1994).

In relation to the influence of ground water on salt accumulation, first of all the so-called critical depth of the ground water table should be determined. This level means the depth below which, owing to natural or irrigated conditions, leaching prevails. It is above this level that salt accumulation takes place in the soil profile. In other words, the salt regime of the given territory is in equilibrium at the critical depth.

When the critical depth is determined, a specific turning point scenario can be elaborated. This will make possible to trace and record the early warning signals concerning the accumulation of salts, coming from below, in the soils.

The following data are needed for the establishment of the salt balance, regardless of the extent of the area concerned:

(1) Total amount of soluble salts at the beginning and at the end of the observation;
(2) The increase of soluble salt content during the observation;
(3) The decrease of soluble salt content during the observation.

Photo 2: Salt accumulation on irrigated soil surface

Three types of salt balance may be identified:

(1) Stable salt balance;
(2) Balance of salt accumulation;
(3) Balance of leaching.

The salt balance of a soil depends on the joint effect of numerous factors, the following of which require mention:

- The depth and chemical composition of the ground water;
- The influence of relief;
- Irrigation techniques;
- Calculation of salt balance.

Given the knowledge of the factors influencing the increase and decrease of the salt content of a soil, its salt balance can be established on the basis of the following equation:

$$b\ m\ a + d + \frac{cv}{M\ t_{fs}}\ .\ 104^{-5}$$

Where:

b = soluble salt content of the soil at the end of the observation in mg/100 g soil
a = soluble salt content of the soil at the beginning of the observation in mg/100 g of soil
c = salt concentration of the irrigation water in g/l
v = the quantity of irrigation water applied during the observation period in np/ha
M = thickness of the soil layer for which the salt balance was established in m
t_{fs} = the bulk density of the soil
d = the salt regime coefficient of the soil in g/100 g soil

The change that has occurred in the salt content of a soil during the observation period is expressed in the salt regime coefficient.

The salinity hazard in irrigated areas should be estimated and, if possible, even determined considering the climatic, geological, pedological,, and agrotechnical factors as well as the technology of irrigation, according to the principle published in *Desertification Control Bulletin No. 21*, pp 36-37 (Szabolcs, 1992).

In the same issue of the *Bulletin* the methods of preliminary survey and the control of irrigated soils are also described.

The mapping of the results of preliminary and subsequent surveys constitutes not only a good display of soil and environmental conditions of the irrigated areas, or areas to be irrigated, but also guidelines for proper irrigation and land protection. Such systems elaborated by various authors for different places and conditions are also available (Szabolcs - Darab - Vdrallyay 1969 a, b).

Thus an adequate water and salinity control system is necessary in which the following factors have to be outlined and thoroughly determined:

- Aim and subject of investigations (the factors and features to be examined);
- Sampling (time, frequency, intervals, methods, etc.) field and laboratory examinations (including mathematical procedures, statistical analysis, possibly a computer program, etc.).

After which the necessary measures based on the evaluated results should be taken for water and salinity control. These measures should prevent the harmful effects of irrigation such as peat formation, salinization, alkalinization, soledization, etc.

Such a system is a precondition of identifying the early warning signals of adverse processes. The tracing and interpretation of early warning signals make possible the efforts to combat the processes of salinization.

Not only is the prediction of soil salinization and alkalinization induced by climatic change necessary, but also the elaboration of methods which can prevent, abort, or diminish the adverse processes. The preventive measures should always be site-specific and in accordance with natural and economic circumstances.

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Sustaining Soil Quality in Dryland Regions

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The problem

Can the dryland agroecosystems of the world be managed for sustaining soil quality, given the cyclical nature of weather patterns and the increasing intensity of use? There is no simple or direct answer to this question, the only thing common to all dryland areas being sparse and variable rainfall. Everything else varies to such an extent that it is impractical to think of global solutions. There are, however, general principles and guidelines for sustaining soil quality that apply globally.

Worldwide population and income growth are increasing demands for food and fibre and will continue to do so into the next century. Most of the increased needs are in developing countries, where it has been estimated that the consumption of staple foods will increase about 2.5 per cent annually throughout the next forty years (World Bank, 1992). In reviewing the potential for meeting increased demands of this order, Srivastava et al. (1993) estimated that only about 25 per cent of the increase can be met through the exploitation of new agricultural lands (mostly in Latin America and sub-Saharan Africa). As a result, much of the increased production required will have to be obtained by increasing the level of output from existing cropland. Also of concern is the slow development of irrigated lands. The world's land area under irrigation reached 206 million hectares by 1978 due to soaring food demand. However, the year 1978 marked the end of the rapid growth in irrigation. Between 1900 and 1950, irrigated areas expanded from 40 million to 90 million hectares, and from 90 to 206 million hectares from 1950 to 1978. From 1978 to 1991, however, irrigated areas only increased by 38 million hectares (Brown and Kane, 1994).

An imbalance between natural resources, population, and basic human needs exists in many regions, but especially in semi-arid regions, and particularly in developing countries. Approximately 21 per cent of the world's population lives in the Warm Seasonally Dry Tropics delineated by latitudes 25° north and south of the equator, with a mean annual temperature exceeding 20°C, and rainfall exceeding evapotranspiration for only two to seven months a year (Srivastava et al., 1993). Millions of people live in vast areas of semi-arid lands in the Middle East, North America, South America, and North Asia. Consequently, production of food and fibre in dryland regions is becoming more important though yields are low and highly variable.

Soil degradation is a serious problem in dryland soils. It is a complex phenomenon caused by a strong interaction between biophysical and socio-economic factors, including increasing rates of population growth, fragile economies, and poorly designed farm policies. Soil degradation can be subtle and slow until a certain threshold is reached, whereupon deterioration occurs quickly and sometimes, irreversibly.

A recent book edited by Pimental (1993) reviewed soil erosion, a major cause of soil degradation, for a number of countries. Two major issues were highlighted - increasing populations and loss of soil organic matter. In that publication, Hurni (1993) reviewed the conditions in Ethiopia and concluded that without family planning, any other development activity is doomed to fail in the long-term. A doubling of the population and a moderate increase of livestock may be sustainable if conservation efforts are practised. However, unlimited growth will lead to land resource exploitation and an almost irreversible ecological disaster within a few decades. Wen Dazhong (1993) stated that the rapidly growing population in China is one reason for aggravated soil erosion. If the population continues to grow, the serious erosion situation will not be improved, no matter how many erosion controls are installed. Even though population control in China is highly successful, it will be impossible to limit the population to less than 1,250 million by the year 2000. Dhoshoo and Tejwani (1993) stated that a very rich civilization flourished in India for centuries. Land degradation in India is a recent phenomenon primarily related to the historical and political ramifications of the latter half of the 19th century and early part of the 20th century. They concluded that human and animal population pressure is the single most critical factor that determines the rate of accelerated erosion. Given the pressure of human and livestock populations and the subsequent misuse and mismanagement of land, the geomorphological, geological, and climatic factors play a secondary role in soil erosion, land degradation, and desertification; only influencing rates of erosion and sedimentation.

While soil scientists and other agriculturalists need to study and document the direct and indirect effects of population on soil degradation, only governments can devise policies and institutions to address population growth. Therefore, soil scientists must focus on management practices that can sustain soil quality and crop production.

Soil organic matter

The loss of soil organic matter is perhaps the most serious factor leading to soil degradation. Several of the chapters in the book edited by Pimental (1993) expressed concern about losses of soil organic matter, particularly in semi-arid regions. Soil organic matter is important because of its positive effect on water retention, soil structure, biological activity, and cation exchange capacity. It is also the source of a large portion of the nutrients needed by plants (Allison, 1973).

Soil organic matter has over the centuries been considered by many as an elixir of life in this case, plant life. Since the dawn of history, man has appreciated the fact that dark soils, found chiefly in river valleys and on broad level plains, are usually (but not always) productive soils. Man also realized at a very early date that soil colour and productivity are commonly associated with soil organic matter derived mainly from decaying plant materials.

Since a sustainable agricultural ecosystem requires the conservation or enhancement of the soil resource base over the long-term, it is imperative that the soil organic matter content of soils be sustained. A decrease in organic matter is an indicator of lowered quality in most soils as it is extremely important in all soil processes biological, physical, and chemical.

For most agricultural ecosystems, the degradation processes and conservation practices occur simultaneously. Soil degradation processes include soil erosion, organic matter loss, compaction, crusting, acidification, salinization, toxicant accumulation, nutrient depletion by runoff and leaching, and waterlogging. These are natural processes that occur to some degree in nearly all cropland areas. As soil degradation intensifies, there is a concomitant decrease in soil quality and productivity. Conversely, soil conservation and reclamation practices are generally applied. Common soil conservation includes crop rotations, water conservation, crop residue management, tillage, cover crops, strip cropping, terracing, use of manures and chemical fertilizers, agroforestry, and contour farming. Therefore, the productivity level of an agricultural ecosystem at any time is a result of the interaction of degradation and conservation/reclamation practices. In natural ecosystems, productivity and sustainability are achieved through the efficient but delicate balance between soil degradation and soil conservation. A sustainable system is any system in which the benefits from soil conservation practices are equal to, or greater than, the negative effects of soil degradation.

Stewart et al. (1991) reviewed the effect of climate and management practices on soil sustainability. They discussed the effects of temperature and precipitation on the development of sustainable agriculture systems. As temperature increases or precipitation decreases, the development of sustainable cropping systems becomes more difficult. And, if these occur simultaneously as in many dryland regions, the development of sustainable crop production systems becomes very challenging. Soil degradation, particularly erosion and decline of soil organic matter, are usually accelerated by high temperatures, and as precipitation levels decrease, there are fewer soil management practices available and biomass production is low, so that the amounts of carbon returned to the soil are insufficient to maintain soil organic matter. Consequently, in hot areas with limited precipitation, the negative processes of soil degradation can easily become much greater than the positive benefits of soil conservation, and soil quality, productivity, and sustainability can drop precipitously.

Experiences from the Great Plains

The dominant dryland region of North America is the Great Plains, occupying parts of ten states in the central United States and parts of three provinces in Canada. Prior to the mid 1800s, this region was considered by most to be similar to the Sahara and was designated on early maps as the "Great American Desert". Dryland agriculture in North America began largely in the late 1800s. The development of railroad transportation and the passage of the Homestead Act of 1862, which provided free land to settlers, led to vast areas of native grasslands being converted to croplands. The settlers brought farming practices from the humid areas; and within a few years, erosion, particularly wind erosion, became serious. Survival, rather than conservation, became the focus of many settlers; and a climax was reached in the 1930s during the infamous "Dust Bowl".

The Dust Bowl has often been described as the worst ecological disaster ever recorded. Wind erosion was so serious that the storms were sometimes called black blizzards. Although the boundaries of the Dust Bowl were never precise, the worst area included approximately 40 million hectares in southeastern Colorado, northeastern New Mexico, western Kansas, and the panhandles of Texas and Oklahoma (Hurt, 1981). Storms were often so intense that lights had to be used during the day. Hurt (1981) quoted, "It seemed as if it were the end of all life". Another likened the darkness to "the end of the world"; and still another professed, "The nightmare is becoming life".

The causes of the Dust Bowl were primarily the characteristics of the soils, the severity of the climate, and the settlement of man. Precipitation is not sufficient during most growing seasons to successfully produce crops so summer fallow was widely used. Summer fallow was defined as a farming practice wherein no crop was grown and all plant growth was controlled by cultivation during a season when a crop might normally be grown. Winter wheat was the primary crop and it was normally planted in September or October and harvested in June or July of the following year. The land was then summer fallowed during the next year, so a crop was only growing on the land approximately eight to nine months every two years. The decline in soil organic matter, coupled with the prolonged drought and bare soils during fallow periods, left the soil highly vulnerable to wind erosion.

Tillage is often essential for increasing infiltration, reducing runoff, and controlling wind erosion, but tillage increases the rate of organic matter decomposition. Therefore, management practices for dryland regions must be carefully chosen, and tillage should be used as sparingly as possible. The stubble mulch system uses subsurface tillage, which results in most of the crop residues remaining on the surface. The system is often called sweep tillage because the plough is composed of sweeps, v-shaped blades that are pulled about 10 cm below the soil surface. Sweeps cut the roots of weeds but bury only about 15 per cent of any crop residues present on the soil surface. This tillage system leaves most of the crop residues on the surface but at the same time increases infiltration and reduces erosion significantly. It slows the rate of organic matter decomposition when compared to more intensive tillage systems. Sweep tillage was the single most important practice developed to control erosion in the United States Great Plains following the Dust Bowl of the 1930s. The sweep plough became known as "the plough that saved the Plains".

More recently, no-tillage is being used in the region to conserve both soil and water. There is a clear relationship between the amount of crop residue remaining on the soil surface and the amount of water stored during the fallow period. Greb et al. (1979) summarized more than 60 years of progress in wheat production in fallow systems in the Central Great Plains (Table 1). As the number of tillage operations decreased, there were marked increases in the amounts of water stored during the fallow periods and dramatic increases in yield. These positive effects tend to accumulate as higher yields result in more residue and increased residue results in more water storage, which translates into higher yields, creating an upward spiral of improved soil quality. The soil's physical properties generally improve, and soil organic matter levels are increased. The more than 100 per cent increase in grain yield was due to several improved technologies, in addition to increased water storage. Improved cultivars of winter wheat in the area have been very important. Plant breeders have also made important developments in other crops. For example, the discovery

Years	Tillage	Tillage Operations (number)	Fallow water storage (mm)	(% of pcpt)	Wheat Yield Mg ha^{-1}
1916-1930	Maximum tillage: plough, harrow (dust mulch)	7 to 10	102	19	1.07
1931-1945	Conventional tillage; shallow disk, rodweeder	5 to 7	118	24	1.16
1946-1960	Improved conventional tillage; began stubble mulch in 1957	4 to 6	137	27	1.73
1961-1975	Stubble mulch; begin minimum tillage with herbicides in 1969	2 to 3	157	33	2.16
1976-1990	Projected estimate:minimum tillage; began no-tillage 1983	0 to 1	183	40	2.69

(Adapted from Greb et al., 1979)

Table 1. Progress in wheat-fallow systems in Akron, Colorado, in the U.S. Great Plains

of cytoplasmic-genetic male sterility in grain sorghum in the early 1950s led to hybrids that had a dramatic effect on yields. Greb (1979) attributed the credit of various improved technologies as follows: water conservation, 45 per cent; wheat varieties, 30 per cent; harvesting equipment, 12 per cent; seeding equipment, 8 per cent, and fertilizers, 5 per cent. The reason for the low impact of fertilizer was because of the long fallow period between crops that resulted in sufficient mineralization of nutrients. Fertilizer has become more important in recent years because of higher yields and the fact that the soils have become less fertile with time. With improved water conservation resulting from no-till, the traditional system of wheat-fallow that produces a crop only one year in two is being replaced by many producers with wheat-sorghum-fallow or wheat-corn-fallow that gives two crops in three years. The fallow period is shortened from about 16 months to about 11 months. Other cropping systems are being studied that will shorten the fallow periods even more. While the improved yields have resulted from a number of technologies, the key is clearly the increased soil water storage. Without increased water storage, the advantage of the other technologies cannot be realized.

Application to developing countries

The lessons learned and the technologies developed in the United States Great Plains are useful in many developing countries where precipitation is also a limiting factor. While the specific technologies cannot be transferred directly because of differences in social and economic conditions, the principles underlying the technologies apply globally. The loss of soil organic matter is perhaps the single most degrading factor to soil quality, particularly in hot and dry regions. Organic matter loss occurs faster in areas of high temperatures, and since precipitation is limited, the amount of organic matter returned to the soil is low. The problem is even aggravated in some developing countries where human and animal populations are dense and most crop residues are used for feed and fuel. Although farmers use of these residues is understandable, serious soil quality degradation often results because of a decline in soil organic matter content. It is critically important that some crop residues, manures, or other carbon sources be added to soils to maintain an acceptable level of soil organic matter and soil quality.

Two recent books, edited by Hatfield and Stewart (1994) and Unger (1994), contain review articles that present the principles of using crop residues for increasing crop production and enhancing the soil resource base as well as experimental results from many locations. These books offer a valuable resource for scientists, change agents, and policy-makers for many parts of the world, particularly for semi-arid regions where the lack of precipitation limits production and soil organic matter loss is a serious problem. Application of these principles is essential to maintain soil quality and productivity, and to encourage the development of sustainable agroecosystems.

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Soil Salinity in China

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Soil salinization is one of the major desertification processes. It adversely affects crop production in about 30 per cent of the 145 million hectares of irrigated land in the drylands of the world (Dregne and Chou, 1992). A special kind of soil salinization called dryland salinity reduces yields in croplands in the semi-arid and subhumid regions of Australia, Canada, Thailand, the United States, and probably elsewhere. Naturally salinized soils are common in the drylands because the rainfall is low and the evaporation rate is high. Irrigated lands can become saline when irrigated with salty water, when the ground water table is close to the surface due to poor drainage or when not enough water is applied to wash the salts out of the soil.

Human-induced soil salinization is the major threat to the sustainability of irrigated agriculture. It has plagued civilizations for thousands of years in the great river systems of Iraq, Egypt, India, Pakistan and China, and continues to be a global problem today. Methods for controlling soil salinity are well-known but putting them into practice on irrigated land is generally expensive and requires a high degree of community cooperation.

A classic paper on the six thousand year history of irrigation in Mesopotamia (present-day Iraq) was published nearly 40 years ago by Jacobsen and Adams (1958). In that article, the authors discussed the results of archaeological studies of the Mesopotamian Plain crossed by the Tigris and Euphrates rivers. Their irrigation records began about 4000 B.C. They noted that by 2500 B.C., the presence of saline patches of soil were reported by temple workers. During the following centuries, a shift in grain crop from a predominance of wheat to a less desirable but more salt tolerant barley attested to farmer adaptation to increased soil salinity.

Water erosion in the hills of the Fertile Crescent complicated the salinity situation. Sediment in the irrigation canals reduced the water carrying capacity of the canal system which, in turn, meant that there was less water available for irrigating crops and for leaching excess salt. High water tables in the slowly permeable soils further exacerbated the salinity problem. By the middle of the 13th century A.D., a thriving irrigated region had become an impoverished, disorganized, and shattered remnant of its former self. Today, Iraq is still recovering from the damage that salt and silt caused centuries ago.

China, which has an irrigation history that rivals Iraq, is suffering increasingly from salinity throughout its arid regions as new irrigation oases are established and old ones expanded. Excessive water erosion on the Loess Plateau of central China is also a threat. Sedimentation of canals and river beds in the loessial region and in the North China Plain is an horrendous problem in the Yellow River watershed.

Saline soils

Saline soils are widespread in coastal areas, especially in closed basins, variously known as *playas, salinas, chotts, sebkhas, salares, nors* depending on what region of the world one finds oneself. In addition, gypsiferous (gypsum-containing) soils contain sufficient soluble salts to qualify as saline, meaning that they have an electrical conductivity of the saturation extract that exceeds 4dsiemens per metre. Naturally saline soils are the result of primary salinization; human-induced saline soils are caused by secondary salinization, which affects mainly irrigated land and rainfed cropland. The latter kind of salt problem is called dryland salinity and it seems that it is largely restricted to the semi-arid wheatlands of Australia, Canada, and the United States.

Ghassemi et al. (1995) estimate that about 20 per cent of the world's irrigated land, in both the arid and humid regions, is salinized. Dregne and Chou (1992) estimate that 30 per cent of the irrigated land in arid regions is saline. The figure for China's aridlands is 21 per cent (Dregne and Chou, 1992).

Two salts, calcium carbonate and hydrated calcium sulphate (gypsum), are not really problematic because of their low solubility and are common components of soils in the temperate arid regions. Gypsum is soluble enough to damage only a few salt-sensitive crops. In fact, moderate amounts of gypsum are generally beneficial because of the favourable effect gypsum has on soil structure and in improving sodic soils.

The damaging soil salts are chlorides of sodium, calcium, and magnesium and the sulphates of sodium and magnesium. Those highly soluble salts interfere with water absorption by plants and can damage plant growth in other ways.

In China, virtually all but the very sandy soils in the drylands are calcareous (contain lime) and many of them are gypsiferous. Unfortunately, a high percentage are also naturally saline (Gong and Lei, 1989; Huang, 1988). China's arid regions are a mixture of (1) numerous high mountain ranges such as the Tian Shan; (2) large basins between the mountains, as in the Junggar and Taklimakan deserts of the Xinjiang Uygur Autonomous Region in far western China; (3) broad gravelly footslopes of hills and mountains; (4) immense sand seas as well as smaller sand dune fields and sandy plains; and (5) abundant permanent and intermittent lakes in closed basins. A large number of lakes in the high mountain valleys of the Tibetan Plateau are saline, as are the intermittent lakes of the playas at lower elevations. Salt seems to be everywhere except in the mountains and the sandy non-irrigated soils. Commercial salt production is carried out in traditional fashion (Figure 1) using large evaporation ponds in dry lake beds.

Human-induced salinization

Secondary salinization of irrigated lands in China is generally due to overirrigation and poor drainage. The rivers supplying irrigation water have relatively low salt contents. For example, the Yellow River at Lanzhou in Gansu Province, where large-scale irrigation from the river begins, contains only about 400 parts per million of salt. Despite that low salinity, major soil salinity problems arise a short distance down the river in the Ningxia Plain and continue in all the irrigated areas along the river until it empties into the Bohai Sea. Excessive applications of water and an inadequate drainage system lead to high ground water tables and the inevitable concentration of salts in surface soils when ground water evaporates. Ultimately, the ground water becomes saline and the entire soil profile is adversely affected.

While salinity affects irrigated areas, some wetlands, and most playas in the arid regions of China, the situation is especially acute along the Yellow River in central China where irrigated areas are spaced like beads on a string. Some have as much as 300,000 ha of irrigated land in a single unit while others may be much smaller. The two largest are on the west and northwest side of the big bend in the Yellow River (Zhao, 1994). The one on the west is the Ningxia Plain in the Ningxia Hui Autonomous Region. The northwest irrigated "bead" is the Hetao Plain in the Inner Mongolia Autonomous Region. The Ningxia Plain has about 300,000 ha of irrigated land and the Hetao Plain something over 300,000 ha.

There are many smaller irrigated oases in the dry regions of central and western China. Most are located in (1) the Hexi Corridor of Gansu Province; (2) many places in Qinghai Province; (3) along the north and south foothills of the Tian Shan; and (4) on the periphery of the Taklimakan Desert. All of them have salinity problems to a greater or lesser degree.

Soil salinity is also severe in the dry subhumid regions of the North China Plain and northeast China. Most of it is due to overirrigation and high water tables but sea water intrusion from the Bohai Sea affects the eastern coastal areas as well.

The Ningxia and Hetao plains are affected by most of the adverse factors that create salinity problems in irrigated soils throughout northern and western China, which include overirrigation, salty ground water, high water tables, low land gradient, high sediment loads in the river, heavy water use for rice paddies and fish ponds, high evaporative potential, and low rainfall. The only major factor missing is sea water intrusion. Yet, despite all these unfavourable conditions, irrigation agriculture on the Ningxia and Hetao plains has been carried out reasonably successfully for 2,000 years. The key question is how long can it continue to be successful now that the Qingtongxia Dam controls the river flow and its reservoir is filling with sediment from the Yellow River.

Figure 1. Salt harvested from traditional pits in playa in western Xinjiang region.

Ningxia and Hetao plain salinity

Climatic and physiographic conditions in the Ningxia and Hetao plains along the Yellow River are similar, and so are their salinity problems. According to the UNESCO Map of the World Distribution of Arid Regions both plains have an arid climate. The ratio of annual precipitation to annual potential evapotranspiration is between 0.03 and 0.2. Average annual precipitation is about 200 mm, most of it occurring in July, August, and September. A continental climate of cold winters and warm summers prevails and the frost-free period is approximately 170 days. Principal crops are paddy rice, maize, wheat, fruits, and vegetables. Many fish ponds have been constructed in recent years, which combine fish production with leaching of fine textured saline soils, enabling the usage of previously abandoned low-lying salty wastelands. Unfortunately, they also raise the water table under the ponds and in adjoining fields.

Figure 2. Characteristic polygons in saline-sodic soil, Yinchuan Plain.

Both the Ningxia and the Hetao plains have such a low gradient that gravity drainage in parts is difficult. Pumps are needed to lower the water table and lift the drainage water into the Yellow River. The land gradient varies from about 1:1500 to 1:8000.

Soils of the plains are primarily deep Entisols and Aridisols overlying Quaternary deposits 1,000 metres or more thick. Many of the irrigated soils have been greatly altered during 2,000 years of irrigation. The principal observable change is the darkening of the upper metre of soil resulting from centuries of manuring. Virtually all of the soils are alkaline, calcareous, medium to fine textured, and moderately permeable. They are excellent agricultural soils, in the absence of excess salt. There are about 23,000 ha of saline-sodic soils (Takyric Natrargids) in the Ningxia Plain. Most of those soils are no longer irrigated. They have a high pH and high exchangeable sodium, as well as high salt concentrations (Figure 2). Above the irrigated plains, soils are generally coarse textured and gravelly, with some sandy soils present, especially south of Baotou.

Ningxia Plain

Canal irrigation began in the Ningxia Plain in 214 B.C., 2,200 years ago, shortly after China was first unified. Since then, irrigation has been practiced continually and the irrigated area has been expanded to approximately 300,000 ha. No dams or water control structures existed on the Yellow River in Ningxia until the multipurpose Qingtongxia Dam was built in 1960. Hydroelectric power is generated at the dam, and the reservoir behind it serves for both flood control and storage or irrigation water. Unfortunately, the reservoir has already lost 70 per cent of its storage capacity due to the accumulation of sediment coming from erosion on the nearby Loess Plateau. A second and much larger dam is scheduled for construction on the Yellow River above the Qingtongxia Dam (Mei, 1994).

Soil salinization is not a new problem in Ningxia. Descriptions were already made in books 2,000 years ago of salt crusts on the irrigated soils as well as statements that cereal crops could not be planted in certain places because of the salt content of the soil and the high water table (Editorial Committee, 1992). As the centuries passed, references to salinity and high water tables became common. A book written in 1617 during the Ming Dynasty (1368-1628 A.D.) even provided a prescription for salinity control. It noted

Figure 3. Abandoned irrigated field due to salt accumulation, Yinchuan Plain.

that water tables had to be kept deep in order to avoid surface soil salinization.

Salt accumulation in the Ningxia Plain is caused by a number of factors. Overirrigation and poor drainage are obvious contributors to soil salinity (Figures 3 and 4) but other conditions are also important. Among them are the flatness of the land, flooding land for lengthy periods when growing paddy rice and raising fish, leaky irrigation canals, and year-round flows of water in major canals that open directly to the Yellow River and which have no water control structures at the entrance to the canals. A soil salinity survey of the Ningxia Plain was conducted from 1975 to 1985, as part of a soil survey of the entire Ningxia Hui Autonomous Region (Design Institute, 1990). The salinity survey data show that there is a definite south-north trend in soil salinity (Table 1). The trend is apparently primarily due to the slopes which are steeper in the southern region and become progressively flatter in the north. Because of that slope difference, drainage is easier in the south and more difficult in the north. The salinity of the ground water also increases in the north due principally to the use of ground water for irrigation in the central and northern region. Water tables are higher in the north as well (Table 2).

Despite the extent of the salinity problem in the Ningxia Plain, crop yields have increased from less than 1500 kg/ha in 1950 to more than 4500 kg/ha in 1990 (Editorial Committee, 1992). The increase has been due to improved crop and soil management practices that have been introduced by research scientists.

Region	Salt affected croplands, per cent Slight	Moderate	Severe	Total, per cent
Southern	19.4	8.6	2.7	30.7
Central	20.9	10.0	4.1	35.0
Northern	24.0	16.8	9.8	48.0
Average	21.4	11.8	5.5	37.9

*Adapted from Xiong et al., 1995

*Table 1. Salinization of Ningxia Plain irrigated soils**

Soil salinity type	Average depth to water table, m	Average ground water salinity, mg/l
Very slight	1.9	1,390
Slight	1.6	1,750
Moderate	1.4	2,340
Severe	1.2	2,770

*Adapted from Xiong et al., 1995

*Table 2. Soil salinity type, depth to water table, and ground water salinity in the Ningxia Plain**

Figure 4. High water table in abandoned saline-sodic irrigated soil, Yinchuan Plain.

Hetao Plain

The second large irrigated area in the middle section of the Yellow River is the Hetao Plain, which is also called the Back Elbow Plain, located in the northwest corner of the big bend in the Yellow River, in the Inner Mongolia Autonomous Region. The geological structure of the Hetao Plain is similar to the Ningxia Plain. Both plains are grabens having a layer of sediment more than 1,000 metres thick and the relief is flat.

In the Hetao Plain, the surface clay is underlain by a sand aquifer which varies in thickness from about 40 to 100 metres and overlies a very thick lacustrine clay layer (Zhang, 1988). Irrigation is accomplished by diverting water directly out of the Yellow River. As a consequence of the flat topography and heavy use of irrigation water, drainage is poor, water tables are frequently close to the surface, and salinity is a major limitation to crop productivity (Wang and Guo, 1992) (Table 3). All cultivated land is irrigated. The average annual rainfall is about 200 mm in the east part of the plain and about 130 mm in the west and the winds are strong and evaporation is high.

During winter and spring, ground water tables decline but generally are within 2.5 metres of the surface. Water tables rise, sometimes to the surface, when irrigation begins and are no deeper than one to 1.5 metres by the end of the season.

In 1965, construction began on an open ditch, a large drainage canal which now runs a distance of 206 km with numerous smaller drainage ditches branching off it. The system is not very effective, primarily because many ditches have become silted as soil sloughs off the banks. Zhang (1988) recommends a combination of drainage ditches with pumping of ground water. Using that combination on a 400 ha test area lowered the water table from 1.4 to 2.2 metres in three years and significantly reduced surface soil salinity (Zhang, 1988).

Irrigation has been practised, more or less continuously, for many centuries. The irrigated area expanded considerably in the 1950s. Salinity has probably been a moderate problem for a long time but has become increasingly worse in recent years. Crop yields are low despite the abundance of water and the richness of the soil. Currently, there are about 340,000 ha of irrigated land.

The upper part of the ground water has a salinity of less than 1,000 parts per million (ppm) but the lower depths are saline, sometimes up to 10,000 ppm. The salt balance in the Hetao Plain is negative: about 1.8 million tons of salt accumulate in the plain each year. Most of the additional salt is from the Yellow River water. Drainage without pumping is particularly difficult because of a large lake in the lowest part of the plain in the northeast interior area. Salinity control depends as much upon making more efficient use of the irrigation water and reducing the amount of water diverted from the river as it does upon drainage. Zhang (1988) says that better water management, alone, can double crop yields.

Year	Area of cultivated land ha	Per cent salinized
1954	223,000	17
1957	332,000	32
1973	367,000	58
1979	231,000	73

*Zhang, 1988

*Table 3. Change in salinized soils in Hetao Plain from 1954 to 1979**

Other regions

Salinity is fairly widespread even in the northeastern provinces of Heilongjiang, Jilin, and Liaoning where the climate is subhumid. Salt affects about 13 per cent of the irrigated land and a little over eight per cent of waterlogged lowlands (Sun, 1988). Moderate to seriously salt-affected cropland amounts to about 1.3 million hectares in the North China Plain (Ghassemi et al., 1995). Most of it is scattered over Hebei and Shandong provinces. High water tables in the irrigated land are largely responsible for the human-induced salinization but sea water intrusion has affected large areas along the Bohai and Yellow seas.

The driest part of China is in the Xinjiang Uygur Autonomous Region in the far west of the country. The Taklamakan Desert, which is a seemingly endless sea of enormous sand dunes, has a hyperarid climate and is a severe challenge to the engineers who are trying to develop its extensive oil deposits. To the north, the Junggar Desert is less dry and less sandy. Between the two deserts are the Tian Shan mountains, which rise to over 5,000 metres.

Nearly all of the lowlands and the lower slopes of the rangelands at the foot of the mountains in Xinjiang are naturally salty. Rivers flowing out of the mountains are of good quality in their upper reaches but become more or less saline by the time they end in closed basins. Salt concentrations in potentially irrigated soils are usually high enough to require leaching when irrigation begins.

Salinization of the lower sections of irrigated oases along rivers in Xinjiang has become worse in the past 10 to 20 years. The reason is the progressive upstream expansion of the irrigated land. As more land is put under irrigation in the upstream areas, less water is available at the tail end of the irrigated area. Consequently, salinity worsens as less water is available for leaching and water tables remain high. Ultimately, much cropland is abandoned because of salinity and water shortages (Wang, 1996). The problem is widespread around the Taklimakan Desert and on the slopes of the Tian Shan. On a much larger scale, that same problem is present in the North China Plain. Already, the bed of the Yellow River is said to be dry in late summer because of increased water diversions for agricultural and industrial uses in the big bend region.

The Tibetan Plateau in Qinghai Province and the Tibet Autonomous Region is covered with lakes at elevations of 4,000 metres or more, most of which are naturally salty (Li et al., 1991). Lake salinity can vary from as little as 500 ppm to as much as 145,000 ppm or more. In these deserts, the world's highest, the mean annual rainfall ranges between about 50 and 200 mm. There is little cultivated land in the montane deserts.

Conclusions

Natural and human-induced salinity are widespread in northern, central, and western China. As a consequence, there is a continual struggle in the irrigated lands to prevent and control salinization. The major problem areas are the Ningxia and Hetao irrigated plains along the Yellow River. However, there are also numerous human-induced salt-affected lands in the northeast, the North China Plain, the Hexi Corridor in Gansu Province, and the oases in Xinjiang. Naturally-saline areas are especially extensive in the gravelly (gobi) soils of Xinjiang and the Tibetan Plateau in western China.

The long-term potential for sustainable irrigation development in China's drylands seems to be gloomy, given the extent and severity of the salinity problem. Yet one should remember that irrigation has been practised in those regions for hundreds and thousands of years. Warnings of salt damage were issued at least 2,000 years ago but irrigation continues and has been expanded greatly, especially in the past 40 years.

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Land Degradation in West Niger

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Abstract

The influx and explosive growth of the population (10 per cent) of Niamey, the capital of Niger, have induced uncontrolled deforestation throughout the hinterland, over-exploitation of the fragile semi-arid cropland, and overgrazing of marginal rangeland and forests.

Accelerated soil erosion and expanding desertification are strikingly visible oil satellite imagery. At current rates of clear-cutting, the forest biome of Niger will have vanished by the turn of this century.

This article gives data on the spatial and temporal change of forest resources, and it analyzes biophysical land surface changes as a result of deforestation both on the plateaux, the glacis, and the bottom-lands (alluvial deposits).

Problem statement

Rural and urban population growth, 3.6 per cent and 10 per cent respectively (Ministère de Plan du Niger 1990) and the associated demand for fuelwood for domestic consumption have induced uncontrolled deforestation and widespread destruction of the semiand forest biome, the "Brousse Tigrée" on the plateau landscape of the "Continental Terminal" in the southwest of Niger. Woodlands in the hinterland of Niamey are cleared at ever growing distances from the city. Rapid top soil loss, irreversible exposure of laterite crusts, increasing surface runoff on the plateaux, gullying and loss of arable land on the glacis, sedimentation and flooding on the bottom-lands, and regional ground water depression are responses of the ecosystem.

Satellite images show a large and expanding circle of barren land around the national population centre of Niamey and around regional centres such as Torodi, Baleyara or Zinder. Such man-made desert islands can neither be reclaimed in the time-span of a human life nor in terms of available financial resources.

This report presents data on the spatial and temporal change of forest resources and on biophysical land surface changes as a result of deforestation both on the plateaux, the glacis, and the bottom-lands.

The study area

Deforestation and land surface have been studied between 12°50' and 13°50' North and 1°40' and 2° 40' East, within a circle of 200 km in diameter, with Niamey slightly to the East of its centre.

Long-term annual rainfall reaches 400 min in the North and 550 mm in the South, placing the area of investigation within the Sudano-Sahelian climatic zone of West Africa.

Three physiographic units prevail: Pliocene sandstones and clay sediments of the "Continental Terminal", covered by a thick iron crust and a thin layer of sand, forming vast plateaux and mesas with steep escarpments 250 to 280 metres above sea level. Nutrientdeficient and at times toxic soils, spatially concentrated in long, curvilinear strips, support the "Brousse Tigrée", a largely combretacean savanna woodland for transhumant grazing. Some 50 metres lower, between talus base and bottom-land, lie the glacis, remnants of the pleistocene dissection of the plateaux. Recent colluvium, eolian sediments, thin residual sandy or clay soils, and ongoing gullying and denudation impose limitations on traditional communal rainfed agriculture, shifting cultivation, and post-harvest grazing on this gently sloping morphological transition zone. Recent linear erosion is remodeling the broad valleys and the bottom-lands - the "Dallols" - about 200 metres above sea level. Deep alluvium and accessible ground water support gallery forests, seasonally irrigated small-scale farming and irrigated village gardening on the slowly draining flood plain and adjacent flat lower reaches of the glacis.

Methods

The rate and extent of deforestation and biophysical land surface changes have been determined.

Landsat MSS imagery for 30 September 1973 and 3 October 1986 (bands 4,5, and 7) was chosen to show temporal and spatial change of (a) forest cover; (b) top soil loss and laterization on the plateaux, and (c) land use on the glacis and bottom-lands. The chosen images encompass the longest time span possible within the Landsat MSS record to keep data sets as compatible as possible with respect to seasonality (end of rainy season) and cloud cover. The early date allows for study of the effect of regional sub-centres on deforestation in the southwest as well as the subsequently added effect of intensified traffic between Niamey and the southwest after the opening of the 'Kennedy-Bridge' across the River Niger in 1972.

Prior to classification, both images have been edge-enhanced and geometrically rectified to the 1:200,000-scale base map. Information from supervised land cover classifications on Landsat TM images (2 June 1987 and 31 December 1987) as well as ground observation data (April 1988) have been used for a first standard Earth Resources Data Analysis System (ERDAS) unsupervised classification on both Landsat MSS images.

The classification has been finalized with input from ground thruthing (in August and September 1989 and May 1990). The original 28 land cover classes have been merged, using visual cues, to a final nine classes land cover legend: forest, shrub, denuded (some harvested) fields, bare soil (some productive), exposed laterite crust or weathered laterite, solid rock (other than laterite), fields in crop (agricultural), and open water (rivers, lakes, seasonal swamps, or ponds).

Ground truthing included surveys of land use on the glacis and bottom-lands, of vegetation density and structure on selected forest and agricultural sites, degree of soil loss, dune and gully development, and general land degradation.

Five small study areas of approximately 15 x 15 km were created from the classified images to magnify details of the impact of Niamey's growing need for fuelwood (see Map. 2). The sites El and E2 ('E' for East, '1' being closer to Niamey than '2') have been located along Route Nationale 25 east from Niamey to Baleyara and the sites SW1, SW2, and SW3 ('SW' for Southwest) Southwest from Niamey to Torodi on Route Nationale 6 to assess deforestation as a function of tune and distance from major markets and from major roads. Some of these sites have been located in areas where recent major irrigation development on periodically flooded bottom-lands and in fossil dry valleys could not bias forest and shrub land cover change information.

Spatial information regarding change and current status of land use and land surface quality with respect to forest, grass and crop production was drawn — in addition to the Landsat data — from Black-and-White 1:60,000-scale photography for 1975 (NIG 1975 40/600), from 1: 70,000-scale B/W photography for 1979 (NIG 1975/700 IRC FAO Zone 1-14, both sets available from IGN / Paris), from Topographic Maps 1:50,000-scale for 1975 (of the Service de la topographie et cadastre de la République du Niger), and from unpublished maps at 1: 200,000-scale for 1988 on soils, vegetation, surface conditions by natural region (produced by the Ministère de l'agriculture et de l'environnement, PUSF, Section inventaire des ressources naturelles).

Soil samples have been taken from forest sites on the plateaux with forest cover of $\geq 60\%$, $50\% \pm 10\%$, $\leq 40\%$ and 0%, from rainfed agricultural sites on the glacis under *Acacia scorpioides*, from fields with average millet stand density, from sites with grass cover (and recent aeolian deposits), and from totally bare (water eroded) sites in the vicinity of productive fields. Six representative sites of each category had been chosen to outline horizontal and vertical changes of physical parameters and textural and chemical soil composition.

Forest resources and deforestation

The forests of varying densities in SW Niger, primarily on the plateaux and to a lesser degree on the glacis and the bottom-lands, are composed of 75 per cent of the species

Guiera senegalensis, *Combretum micranthum*, *Combretum nigricans*, and to a lesser degree of *Acacia ataxacantha*, *Acacia macrostachya*, *Bombax costatum*, *Boscia angustifolia Boscia angustifolia*, *Boscia senegalensis*, and *Combretum glutinosum* (Ministère de l'hydraulique et de l'environnement; PUSF 1986). Indiscriminate deforestation in the immediate surroundings of Niamey during the 1960s - at that time a mere collection of smaller villages - had left only minor marks on the landscape; the 1973 image still shows a healthy forest cover on all plateaux to the NW, N, NE, E, and SE of the capital (Map 1). Only

Map 1: Land surface cover in Southwest Niger: Landsat MSS 1973

escarpments show exposed laterite crusts as a result of intensified fluvial erosion and continued slope dynamics. Prior to 1973 the forests to the south west of Niamey did not supply the market of the capital, due to minimal traffic across the River Niger until the opening of the Kennedy Bridge in 1972. Nogaré — Niamey's smaller twin-city on the right bank of the river — had placed even more modest demands on nearby forests; here as well as in the vicinity of Torodi — the regional sub-centre 60 km south west of Niamey — the plateaux show dense forest cover with laterite exposed only along the outer margins of plateaux in close proximity to the major highway.

By 1986 Nogaré had become part of the market of Niamey, and local fuelwood demands from Torodi became subordinate to the mushrooming energy demand of the capital (Map 2). The forests have disappeared on the right bank of the Niger and along Route Nationale 6 to Burkina Faso up to a distance of over 45 Km; towards the E, NE, and SE of

Niamey the forests have been completely harvested along all major highways to about 40 km distance from the capital with even greater spatial depth than in the south west; note the striking increase of very dark (laterite) and very light (denuded and bare soil) areas. In this deforested "island" only irrigated croplands appear as green. Previously densely forested plateaux are now lateritic wasteland that has lost its protective soil cover within five to ten 10 after clear-cutting and thus has been deprived of any means for an ecological recovery. To both sides of the Niger the degree of deforestation, denudation, and laterite exposure is directly related to the proximity of the market of Niamey.

The five study sites provide the necessary details:

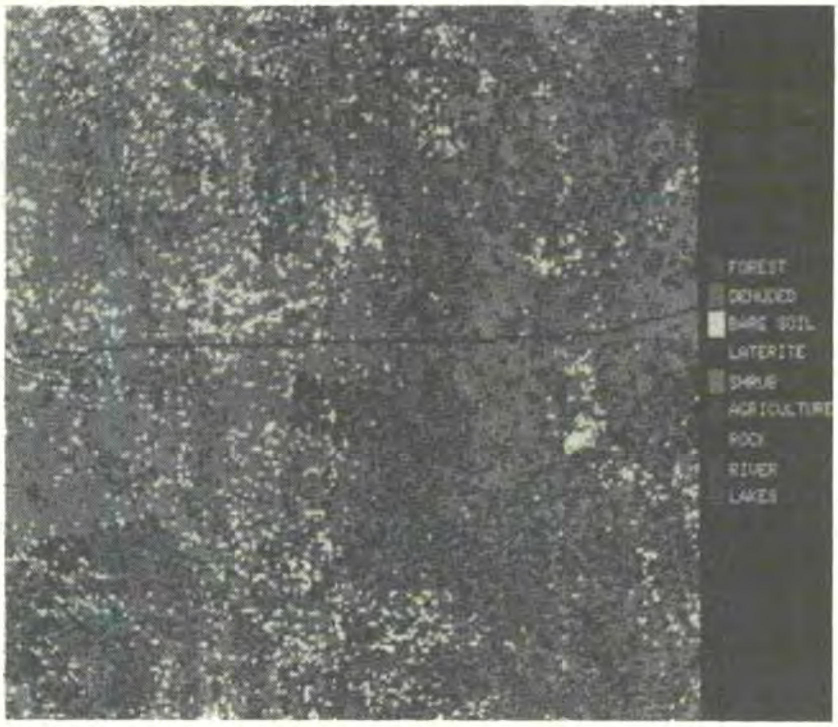
- El and E2 1973/1986: In 1973 the protected Forêt classée de l'avion in the south west corner of El is still under conservation (Map 3); the system of plateaux along the western edge of El 13 km E of Niamey are deforested. The plateaux of the entire eastern half of El, however, are still covered with forests, all of which had disappeared by 1986 (Map 4). As late as 1973, Hamdallay, in the centre of E2, had been surrounded by densely forested plateaux; by 1986 both forests and soil resources have disappeared exposing laterite crusts. Cultivation expanded; wind impact and lack of conservation has increased denuded and bare surfaces. - SW1, SW2, and SW3 1973/1986 : Change followed a different pattern in the south west; in 1973 deforestation had exposed lateritic plateau edges that became increasingly wider with growing proximity to Torodi, the regional sub-centre halfway between Niamey and the international border. At this time, however, the south west did not serve as hinterland for the capital. Forest cover in general had been dense enough to effectively protect the ecosystem on the plateaux.

Map 2: Land surface cover in Southwest Niger; Landsat MSS 1986

By 1986 this E-W-gradient of deforestation had been reversed. The impact of the sudden opening of the south west for the market of Niamey after 1972 can be noticed not only along Route Nationale 6; laterite crusts retrace most secondary and tertiary access roads to the plateaux; they penetrate deep into every watershed, with greatest laterite frequency closest to the Niger Valley.

Landsat imagery is recording "forest" only for areas with $\geq$50 per cent forest cover. Areas classified as "bare" or "denuded", therefore, are not necessarily "totally deforested"; in such transitional scenarios on the plateaux, forest cover of $\geq$50 per cent is classified as "denuded" or "bare" soil (depending on the productivity of the site), as long as the laterite crust remains unexposed. In most water erosion and grazing scenarios, however, the productive soil cover will be totally removed within five to 10 years after clear-cutting. The vast majority of plateau landscapes within the "deforested island" around Niamey is classified as "laterite" — an indicator for the total absence of tree cover. Planimetric measurements can use the sharply identified perimeter of the plateau escarpments for reference.

In the wake of increasingly restricted forest grazing on the lateritic plateaux throughout the entire image, the belt of rainfed agriculture on the glacis had come



Map 3: Land surface cover in Site El: Landsat MSS 1973

under mounting grazing pressure, rendering growing numbers of acres barren (bare soil) and unsuitable for future crop production.

The forests on the glacis and the bottom-lands with potential for irrigation are cleared of forests on the plateaux and there is increasing demand for communal rainfed arable land. Rainfed agriculture expands in all study sites ("denuded" for harvested or idle fields).

Rainfall preceding the 1973 image date had been roughly 25 per cent less abundant than rainfall that supported the vegetation in the 1986 image; the true dimension of the general decline of forest and shrub cover, therefore, is masked by these favourable (pre-fall) 1986 rainfall events.

Summarized ERDAS statistics compare landcover classification percentage changes from 1973 to 1986 (Table 1). For the entire image forest cover decreases from 17.04 per cent to 13.71 per cent, shrub cover from 21.34 per cent to 14.36 per cent. The ERDAS Classification Routine, since it operates on digital number values, cannot be refined to discriminate between similar cover types like green trees or irrigated plantations. The dramatic increase in irrigation acreage along the Niger River, its periodic tributaries, and in all dry river valleys with fossil ground water between 1973 and 1986, therefore, reduces the percentages for general loss of forest cover; the 23 per cent "forest cover" in SW3 1986 in fact accounts mostly for irrigated waterlogged bottom-lands along the Goroubi River and its tributaries. As a response to the relative decrease of forest cover, but also as a response to actual areal expansion, percentages of bare soil and denuded soil increased from 1973 to 1986. In the absence of large-scale irrigation in both SW1 and SW2, laterite, forest, and shrub percentages do reflect true spatial land cover changes. Visual and planimetric comparisons provide evidence for rapidly expanding lateritic plateaux and devastated agricultural areas in all other study sites.

For detailed spatial-temporal information see the complete set of full-coloured Maps and the complete project report in Späeth 1995.

Biophysical land surface changes

Deforestation accelerates morphological processes the most evident of which are (a) on the plateaux: mobilization of fossil dunes, solum trunkation, laterization, and recession of escarpments; (b) on the glacis: sheet erosion, slope dissection, gullying, top soil loss, and eolian deposition and (c) on the bottom-lands of the Dallols:

Map 4: Land surface cover in Site El: Landsat MSS 1986

SURFACE	E1 73	E1 86	E2 73	E2 86
Background	.00	.00	.00	.00
Forest	14.24	4.18	24.03	9.14
Denuded Plain	36.31	57.86	17.55	47.19
Bare Soil	6.37	11.17	4.10	13.79
Laterite	30.94	18.26	37.59	17.47
Shrub	11.07	5.49	16.30	9.64
Agriculture	.15	.04	0.19	0.07
Laterite Slopes	.18	2.00	0.15	2.12
River	.00	.00	.00	.00
Water, Lakes	.74	.43	0.09	0.01

SURFACE	SW1 73	SW1 86	SW2 73	SW2 86
Background	.00	.00	.00	.00
Forest	23.18	8.90	13.44	10.51
Denuded Plain	2.80	24.27	4.19	18.20
Bare Soil	0.88	2.81	1.51	2.55
Laterite	30.88	37.37	39.10	44.84
Shrub	39.08	20.49	37.17	12.10
Agriculture	1.33	0.18	1.28	0.56
Laterite Slopes	1.60	4.80	2.58	10.34
River	.00	.00	0.25	.00
Water, Lakes	0.24	.00	0.48	0.22

SURFACE	SW373	SW3 86	1973	1986
Background	.00	.00	.00	.00
Forest	16.26	23.72	17.04	13.71
Denuded Plain	6.83	24.81	19.42	33.88
Bare Soil	4.50	7.22	6.21	9.56
Laterite	31.66	19.66	32.74	21.20
Shrub	33.03	15.10	21.34	14.36
Agriculture	3.39	0.78	1.03	0.55
Laterite Slopes	4.20	7.51	1.26	5.86
River	.00	.00	0.61	0.80
Water, Lakes	0.12	.00	0.36	0.08

Table 1: Changing land surface cover (in percent) for the entire image and the five study sites in the vicinity of Niamey / Niger from 30 September, 1973 to 3 October, 1986 (tropical dry climate; Thorn savanna; 300 - 500 mm annual rainfall; landsat mss)

alluviation of drainage channels, floodplain expansion and flooding, dune development. These processes can be remotely sensed and monitored and brought to the attention of policy makers. But long before these dramatic morphological processes — signaling the final collapse of the ecosystem at large - become evident, less spectacular — but no less devastating — changes are affecting the soil resources reducing productivity at an accelerating rate and sending early warning signals to the local farming community.

Soils in the Forests on the Plateaux

Samples have been taken in mid-September from sites with near 100 per cent forest cover (Scenario 1. 1), from sites with 40-60 per cent forest cover (Scenario 1. 2), from sites with < 40 per cent forest cover (Scenario 1. 3), and from sites that have lost all forest, shrub, herbaceous vegetation and productive top soil (Scenario 1.4).

Soils in scenario 1.1 are generally dark and deepred, maintaining their colour, high moisture content at pF 3, (clayey) consistency, and texture throughout the entire depth of the solum. Soil clod stability is excellent; surface permeability is moderate at about 20 mm/h.

As forest cover approaches 50 per cent, soil colour chrome and value indicate diminishing organic matter. Surface soils are losing the highly mobile grain diameters, increasing the relative share of the less mobile sizes. These changes translate into reduced formation of erosion resistant soil clods and decreasing soil moisture storage. Depth of solum is reduced; below 30 cm depth compaction is noticeable, consistency is reduced, and small weathered rock fragments are beginning to prevail — an indication that the surface of the weathering iron crust in about 50 cm depth. Surface permeability is moderately slow at about 10 to 15 mm/h.

Sheet erosion, periodic flooding, and deposition produce trunkated and highly stratified/interbedded soil profiles on areas with <40 per cent forest cover (scenario 1.3). Thin clay layers interbed with imported skeletal soils in the upper horizon. Below 30 cm depth small weathered rock fragments abound; the surface of the weathering laterite crust is close. Soil clod stability at the surface is moderate to poor; surface permeability is slow (at <5 mm/h) but varies widely in accordance with the site's most recent erosion and sedimentation history. These sites are at a critical stage of development; ecological recovery is still possible, especially where water harvesting techniques can enhance soil moisture budgets in bare and grassed-in locations.

The unprotected surfaces in scenario 1.4 — but also in scenario 1.3 — are subject to wind and water erosion; within a few (five to 10) years the solum disappears, often exposing the weathering surface of the iron crust. Pleistocene dunes are reactivated; their sands are washed away or blown onto the glacis and into the dallols. Exposed skeletal subsoils withstand further removal for some time; larger weathered components are varnished. Moisture content is minimal at pF 4. Skeletal soils retain illuviated finer soil materials, which in turn compact during the dry season. These sites are beyond rapid reclamation.

Vertical distribution changes of organic matter, pH and calcium reflect continued alternating soil loss and deposition rather than sequential soil loss events.

Table 2 summarizes soil texture and chemical properties change as a function of deforestation, overgrazing, and erosion in these four forest plateau scenarios. Highly localized and interactive conditions of terrain configuration, original soil properties under climax vegetation, ground cover, terrain climate, and surface drainage result in a wide spectrum of physical and chemical profile characteristics.

Soils on the Glacis

Table 3 outlines typical soil texture and chemical property changes as a function of shortened fallow cycles, overgrazing, sheet erosion, and wind deposition in the rain-fed agricultural sector of the glacis: cultivated sites under isolated trees or groups of acacia trees (scenario 2. 1), currently productive millet fields (scenario 2.2), depleted former fields now idle under grass cover (scenario 2.3), and eroding unproductive bare soil (scenario 2.4). It should be noted that glacis are a transition zone, morphologically participating in both past and current processes of fluvial and eolian denudation and deposition. The result is a solum that varies greatly from the theoretical catena model.

All herbaceous scenarios on the Glacis share one feature: the presence of fine sandy deposits in the surface layer originating from the newly activated fossil dune fields on the plateaux.

In the shelter of individual deep rooting indigenous *Acacia albida* or *Acacia scorpiodes* (scenario 2. 1) improved supplies and recycling of nutrients and microclimatic conditions lead to higher and denser millet stands (and higher grain yields), to improved mulching and soil management potential, to stimulated soil-biological activities and enhanced textural qualities (approaching a loamier matrix), to improved soil moisture retention both at Permanent Wilting Point and even more so at Field Capacity, and to improved clod stability and erosion resistance. At

a. Scenario b. Site c. Sample	Clay	Silt mm diameter		Sand				pH (KCL)	O.M. %	$CaCO_3$ %
a.b.c.	<0.002-	0.002- 0.0063	0.0063- 0.2	0.02- 0.063	0.063- 0.2	0.02- 0.63	0.63- 2.00			
1.1.1	46.	5.75	6.95	11.65	18.1	7.35	2.9	4.17	7.6	0.27
1.1.2	45.75	8.7	7.7	7.6	18.0	8.85	2.55	3.91	9	0.31
1.2.1	34.05	4.2	8.3	10.9	23.05	11.65	3.15	3.84	6.9	0.23
1.2.2	28.45	4.45	10.3	13.05	11.55	8.85	19.5	4.01	9.8	0.33
1.3.1	39.45	3.3	6.85	10.1	21.15	15.2	3.0	3.85	8	0.27
1.3.2	44.05	2.05	4.05	4.4	23.75	17.9	3.55	3.94	6.1	0.25
1.4.1	25.7	2.3	6.05	12.5	28.35	14.75	7.75	4.11	5.3	0.31
1.4.2	33.0	2.7	5.15	9.45	22.7	15.1	9.65	4.13	7.0	0.29

*) Sample No. 1 from 0-30 cm depth; Sample No. 2 from >30 cm depth.
Further explanation in text.

Table 2: Physical and chemical properties of soils on forested plateaux

a. Scenario b. Site c. Sample	Clay	Silt mm diameter		Sand				pH (KCL)	O.M. %	$CaCO_3$ %
a.b.c.	<0.002-	0.002- 0.0063	0.0063- 0.2	0.02- 0.063	0.063- 0.2	0.02- 0.63	0.63- 2.00			
2.1.1	23.75	0.95	2.45	5.45	30.8	33.1	2.6	4.25	2.6	0.16
2.1.2	34.55	1.1	3.25	6.7	27.1	25.1	1.9	5.79	3.8	0.17
2.2.1	19.55	0.9	2.5	5.5	34.7	32.8	1.9	4.45	2.0	0.18
2.2.2	33.75	0.6	3.25	10.1	25.15	24.55	1.85	4.66	3.5	0.25
2.3.1	16.15	0.15	0.3	2.9	44.2	32.95	0.8	4.22	1.5	0.19
2.3.2	35.75	0.2	2.05	5.75	26.1	25.65	2.85	4.22	3.9	0.20
2.4.1	28.65	0.3	2.05	5.55	28.9	29.45	2.1	4.07	3.0	0.23
2.4.2	37.15	0.9	2.1	7.95	26.25	22.95	2.0	4.15	3.9	0.29

*) See Footnote on Table 2

*Table 3: Physical and chemical properties of soils on glacies under dry-farming in Southern Niger**

the same time, organic matter decomposes faster and eolian deposits are retained more effectively than elsewhere on the glacis giving the surface soil a sandy matrix. The solum is over 60 cm deep, changing texture (higher clay content), colour (to a darker brown), and increasing consistency in about 40 cm depth. The average millet field (scenario 2.2) shares these characteristics, the dimensions of the field determine the volume of captured eolian sediments and physical surface characteristics. Permanent tillage with the archaic 'hilaire' and mulching keep surface permeability of these sandy sites moderately high at about 50 mm/h; moisture content remains minimal at pF 4. Soil clods at the surface disintegrate readily showing little erosion resistance. Relatively slightly higher contents of highly mobile grain sizes below the current eolian top layer, often interbedded with layers of clay, can improve available soil moisture. These lower strata of the solum in fact, everywhere on the glacis—contain tropical clay and loam interbedded with fine sand both washed off and blown in from the plateaux.

Depleted former agricultural sites, currently under grass (scenario 2.3), retain the bulk of eolian sediments during the dry season, thus enhancing surface infiltration and reducing moisture storage potential. Top layers (20 to 30 cm) are distinctly lighter in colour and less consistent than underlying horizons. Lateral erosion has reduced the extent of these grassy sites, which rise about five to 15 cm above the surrounding bare soil (scenario 2.4 The perimeter is constantly being reduced by lateral erosion by sheet floods on the adjacent devegetated areas.

Depleted former agricultural sites, now totally bare (scenario 2.4), show highest clay contents in both top and sub-surface layer. Colour and high consistency remain unchanged throughout the soil profile. Surface clod stability is excellent, but seasonal sheet erosion further damages these sites. Gullying is common along all linear drainage arteries.

This sequential loss of productive top soil is further evidenced by the vertical changes of organic matter and calcium.

Outlook

Village chiefs and heads of households recognize a development they no longer control: the lack of sustained long-term conservation-oriented rural development policies, removed and centralized decision-making, and progressive monetization of village economies which are counterproductive to ecological recovery and survival of indigenous village-based production and insurance systems. At the current advanced stage of environmental exhaustion the tree-based farming system has no future — mainly due to the mounting urban demand for forest products. Controlled external economic input into the village economy is expected to help preserve a modified version of the former rural social and economic make-up — provided that the remaining productive soils and forests can be preserved.

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Acknowledgements

This research has been supported by the National Geographic Society, Washington, DC / USA; the National Science Foundation of Germany; Maman Guéro (PUSF/ Niamey); Garba Ide (University of Niamey/Niger); my son Oliver Spaeth, Cornell College, Mt. Vernon, Iowa / USA; Jan de Winter (DFS / München); Adamou Aboubacar (University of Niamey/Niger); and Hans-Karl Barth, Universität Paderborn. Research Permission was granted by le Ministre de l'enseignement supérieur, de la recherche et de la technologie du Niger.

Community-based Management: the *"Gestion des Terroirs"* Approach[1]

Jeffrey Lewis

The World Bank
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Community-based land management arose from the ashes of the 1970s and 1980s generation of sectorally focused, top-down production and rural development projects. These had little sustainable impact, only marginally involved the population in decision-making, and usually ignored the management of the natural resource base on which local production systems depend. This situation led to a re-orientation of government and donor strategies and a new generation of decentralized, participatory, multisectoral and flexible projects.

Interest in community-based land management has grown considerably in West Africa over the past ten years. Virtually all major donors and a significant number of non-governmental organizations have become involved. The strategy is included in the national environmental action plans of a number of countries in the region, it has been adopted by the fourteen countries in the onchocerciasis (river blindness) eradication programme as a strategy for areas liberated from the disease, it is a major component of the International Convention on Desertification, and it is being used in wildlife management and biodiversity conservation projects. In Burkina Faso, Mali, Côte d'Ivoire and Niger, there are now 80 ongoing projects embracing the approach representing a total investment of more than US$ 450 millon.

Some key terms which are frequently misused need to be clarified. **Environmental management** is a general term covering all aspects of the global environment, including issues such as biodiversity, global warming, pollution, water quality and the ozone layer in addition to land and natural resource management problems. **Natural resource management** is a specific term focusing on the management of soil, vegetation and animals in the agro-sylvo-pastoral system. Biodiversity and water resources may be included, but minerals are usually not. **Community-based land management** or *"gestion des terroirs"* includes not only natural resource management interventions, but also other supporting actions to respond to a community's whole range of development priorities, such as spatial planning, improved production and household incomes, and development of socio-economic infrastructure.

Description of the *"gestion des terroirs"* approach

The objectives of *gestion des terroirs* are: (1) to provide communities with the operational capacity to initiate and implement activities to improve production, quality of life and the environment; and (2) to provide communities with the authority and administrative and legal power to manage their land resources.

There are eight steps in the process: development of a supportive framework at the national and community level; a participative diagnostic survey; identification of goals, resources available and needs; preparation of a preliminary development plan identifying priority actions- review of the plan; negotiation Of financing; implementation; and monitoring, evaluation and annual adjustment of plans.

The approach is participatory, open, flexible and iterative. It is based on the community's knowledge of their land and its resources, their needs and priorities and the possible solutions to their problems.

The following are the key elements of the approach. They depend to a large

[1]This is an edited extract of a draft paper by Jeffrey Lewis entitled "Community based land management in West Africa: a review of current field experince" (Lewis 1995)

degree on supporting national policy and the institutional and legal framework.

- *Participation* of local communities and the users of local resources is crucial to long-term success and internalization. Participation includes the legal right to assume authority and responsibility for land and resource management. The project cycle begins with a participatory diagnostic evaluation by the population of their resources and needs. Outside agencies need to change the way they work to implement a participatory strategy, and develop the capacity to listen to people.
- Local *coordination* through a coordination committee is needed to ensure that intersectoral and interagency coordination as well as cooperation among government services, non-governmental organizations and the private sector takes place. A transparent process and precise definition of responsibilities is required.
- *Security of tenure* is a precondition to the long-term success of natural resource management operations. The problem of overlap between traditional land tenure arrangements and modem legislation can often be resolved by bringing resource users together to discuss specific conflicts on a case-by-case basis, thereby avoiding litigation. *Gestion des terroirs* can help provide a framework for discussion and conflict resolution, and clarify the interests of various resource users.
- *Decentralization* entails a transfer of power from government authority to local community groups such that they become legally responsible for resource management. It also involves decentralization of government responsibilities from central state structures to those closer to the population.
- The speed with which the approach can be implemented is controlled primarily by the rate at which *local capacity* can be built for management and implementation. Human resource development, training and field visits, and implementation of priority actions the community have proven to be effective ways of reinforcing building local capacity.
- The overall and diagnostic process must encompass the fill range of concerns population, including *special interest groups* such as women, youths, migrants, and other resource users.
- Development of infrastructure such as wells, schools and clinics invariably emerges as a primary concern of the population. The strategy must therefore take into account the need for *supporting investments in social infrastructure* as well as natural resource management.

Careful monitoring of progress and regular revision of plans provides *flexibility* and allows the project to react to changes in capacity, local conditions and opportunities.

Lessons learned

Important lessons about community management of land resources have been learned through the implementation of the *gestion des terroirs* approach. These have been discussed in detail elsewhere (Lewis 1995, Club du Sahel/OECD 1995, Ministère de la coopération et La Caisse francaise de développement 1994, UNSO 1995).

One conclusion from these lessons is that there is considerable activity in this area, and significant modifications have already been made in the approach. This reflects a healthy dynamism and an empirical process of "teaming by doing" facilitated through networking, dialogue among the partners and a willingness to share criticism, information and experiences. The most positive aspects of the process depend on goodwill, interest and enthusiasm: the "human nature" factor which unfortunately is impossible to formalize or replicate.

Further development of the *gestion des terroirs* approach will require that existing operations accelerate and resources are mobilized for rapid, wide application of the approach to as many communities as possible. It is also important that all key actors in the rural areas internalize the approach, allowing free-standing *gestion des terroirs* operations to be phased out.

There are a number of serious and worrying gaps in skills, knowledge and understanding of the approach. For example, an effective system for monitoring impacts is not available the economic impacts of *gestion des terroirs* are poorly understood, it is unclear how *gestion des terroirs* can contribute to decentralization and clarification of tenure issues, and the effects of a future withdrawal of field teams from villages has not been considered.

The *gestion des terroirs* approach responds to one of the most serious problems of the region, is basically sound, and is accepted by the population. Human resources and training modules to staff the programme exist, and technologies to resolve the most serious resource problems are known. The *gestion des terroirs* programme which was started in West Africa should now continue in that region and expand, with suitable adaptation, into other parts of Africa where it is not yet being applied.

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[1] This is edited extract of a draft paper by Jeffrey Lewis entitled "Community-based land management in West Africa: a review of current field experience" (Lewis 1995).

NEWS FROM UNEP

Seventh Meeting of the African Deserts and Arid Lands Committee (ADALCO), 6 - 8 December, Harare, Zimbabwe

The meeting aimed at:

1. Reviewing and analyzing Sub-Regional Action Programmes preparation with a view to coordinating and harmonizing strategies, approaches and programmes;
2. Identification of programme elements, approaches and coordinating mechanisms for preparation and follow-up on the Regional Action Programme.

Background

The ADALCO Experts Group meeting convened in Bobo Dioulasso, Burkina Faso in November 1994 by the chairman of the Committee, reviewed the Committee's objectives, strategies and programmes, and recommended a shift from national to sub-regional and regional levels. This was with a view to adapting the objectives of the committee to the provisions of the newly adopted Convention to Combat Desertification (CCD), the Regional Annex and the Urgent Action for Africa. The Experts Group meeting recommended that the African Deserts and Arid Lands Committee should serve as permanent mechanism acting as a technical instrument to support regional and sub-regional efforts, in order to coordinate and harmonize the implementation of the Convention at sub-regional and regional levels.

Within the framework of its new mandate, the Committee convened the Harare meeting with a view to gathering sub-regional organizations' representatives for coordinating and harmonizing their approaches and strategies in the context of the Convention implementation. It also sought to identify a coordination mechanism for preparation of the Regional Action Programme, as anticipated in the Convention texts, particularly, article 13 of the Regional implementation Annex for Africa.

The Executive Secretary of the CCD and the OAU representative made presentations on identification of elements and approaches for the elaboration of a Regional Action Programme for Africa and identification of a Regional Coordinating mechanism.

In their presentations, they proposed the establishment of a small and streamlined Regional Coordinating Unit comprising two or three staff to implement the relevant part of the Convention and the Regional Annex for Africa (Article 13), related to the preparation of a Regional Programme of Action for Africa, as the Convention does not elaborate on the institutional arrangements to deal with the regional level. It was proposed that a Regional Coordination Unit within existing structures be set up, (for instance within the African Development Bank).

Training Programmes within the National Land Degradation Assessment and Mapping Project in Kenya

The National Land Degradation Assessment and Mapping project in Kenya, a joint project of the Governments of Kenya, The Netherlands and UNEP was designed to improve on methodologies for land degradation assessment and to extend the products, procedures and technologies to the senior technical officers of the Government of Kenya and the NGOs who are concerned with the planning and implementation of development projects at national and district/community levels. This was done in two ways:

First, the entire project was, for the most part, developed by a team of senior technical officers from Government institutions, with technical assistance from UNEP. The same trend was followed during implementation by involving a team of over 25 senior technical officers from the same institutions who acted as resource persons within the study.

Second, land degradation is a major concern of not only the land users themselves, but also a large number of governmental and non-governmental institutions, organizations and projects which are involved in policy setting, planning and implementation of rural development projects. There are also a number of regional and international organizations which, through partnerships with the Government, support various activities concerned with actions to combat land degradation.

Within the project, four workshops were organized: one at national and three at district levels. The National Environment Secretariat of the Government of Kenya provided the administrative services while the leaders of the various thematic indicator teams were responsible for presentation of project outputs.

The national workshop was organized in Nakuru from 1 to 4 November 1995. It was attended by over 50 participants who were senior technical officers from Government ministries. These ministries have central planning units at headquarters as well as technical staff from river basin development authorities. International NGOs and donor agencies were also represented.

The district level workshops took place in Mombasa (for Coast and Eastern Provinces) from 10 to 13 January 1996, Eldoret (for Rift Valley Province) from 24 to 27 January 1996, and in Kakamega (for Western and Nyanza Provinces) from 7 to 10 February 1996. Each of the workshops attracted 40 participants comprising mainly the technical heads of departments at district headquarters. A number of NGOs and donor projects based or operating in the relevant districts were also represented.

The national workshop focused on the technical aspects of the results while the district workshops focused on the application of the results and access to the database. In addition to a number of suggestions for an improvement in the indicators, the workshops made several recommendations including the following:

i) In view of the potential value of the national land degradation assessment database in facilitating planning, monitoring and research in the field of land degradation assessment, the database should be made easily accessible to policy makers, administrators, developers, research institutions and other relevant bodies;
ii) The issue of copyright should be clearly defined and appropriate provisions made to allow easy access while safeguarding the database;
iii) There is need for a management/ advisory committee for the database, a centralized institution to look after the database, and effective networking connections between the central institution and other key institutions that are involved in the generation of the information or are regular users of the information contained in the database;
iv) In order to promote the use of the database, demonstrations should be organized in the form of workshops at strategic focal points. The mass media could also play an important role in this process.

Workshop on the Panel of Experts on Desertification Control in Asia and the Pacific,

6 to 9 December 1995

Organization

The Workshop of the Panel of Experts on Desertification control in Asia and the Pacific was held at the United Nations Conference Centre in Bangkok from 6 to 9 December 1995. The Workshop was organized by the Economic and Social Commission for Asia and the Pacific, (ESCAP).

The Workshop was attended by a panel of experts from selected member countries of the Regional Network of Research and Training Centers on Desertification Control in Asia and the Pacific (DESCONAP) and the ESCAP, UNEP, FAO and INCD secretariats.

The Expert Panel was convened to discuss the follow-up of the Commission resolution 51/11 on strengthening DESCONAP. The Panel discussed the programme of activities of DESCONAP to highlight necessary issues for further strengthening the network and to bring to their attention the high level meeting as envisaged in the ESCAP resolution 51/11.

The Panel noted that there was a regional meeting at Yangon in April 1996 to discuss follow-up to the United Nations Convention to Combat Desertification (UNCCD). Another sub-regional meeting was also held at Almaty to discuss follow-up to UNCCD in the countries of the Commonwealth of Independent States (CIS). It asked in this context that the Panel review the work programme of DESCONAP and the terms of reference of the DESCONAP Programme Office (DPO) to implement it.

The Panel also noted the positive contributions made by DESCONAP as a functional forum in creating awareness of the problems of desertification and its control in the region through the exchange of experience, study tours and field visits. In particular, its role in the formulation of the Asian Annex to UNCCD was highly commendable. The Group was of the view that DESCONAP might play a lead role in the coordination and implementation of the programme of action envisaged in the UNCCD. In these efforts, cooperation will be sought from sub-regional organizations including the Association of South-East Asian Nations (ASEAN), Economic and Cooperation Organizations (ECO) and South Asia Cooperative Environment Programme (SACEP), together with the

Asian Development Bank, the World Bank, the Global Environment Facility, the Bank for Economic Reconstruction and Development, and the Islamic Development Bank. In order to achieve this, the need for a considerable strengthening of the DESCONAP network was emphasized.

The Panel also took note of the two networks; the Soil Conservation Network in the Humid Tropics and the Network for Assessment of Soil Mapping operated by FAO, whose experience could be used as background in formulating the work programme of the DESCONAP.

The Panel noted the importance of the socio-economic aspects of desertification in the Asia-Pacific region because of the large number of people affected by the process of desertification. The Convention provides the forum to address these issues. On the other hand, follow-up action should be prepared by the countries and should involve the donor countries/organizations in order that all participants in the process lend necessary support for its implementation.

The participants discussed at length the Terms of Reference (TOR) of DPO. At the same time a strong emphasis was put on the appropriate methodology for conducting the consultative process leading to the preparation of National Action Programmes to Combat Desertification (NAPCD). National coordinators for NAPCD would ensure active participation of grassroots operators in the programming process and initiate informal contacts with in-country donor groups so as to ascertain modalities of partnership programming in the light of Article 4.1.i of the Regional Implementation Annex of Asia (RIA). Given the importance given by the RIA to integrated local development programmes in the affected areas (Article 4.2 RIA), the investment banks should be associated with the early steps of the NAPCD process. The ESCAP Secretariat was therefore requested to inform the appropriate units of the Asian Development Bank.

The ESCAP Commission, at its 51st session, had urged the members of DESCONAP through resolution 51/11 to provide further support for its strengthening and requested the Executive Secretary in collaboration with UNEP to convene a high level meeting of the Regional Network to develop a work programme of the Network and to elaborate further on the role and mandate of DPO.

- The expert panel agreed on the TOR for DPO and on the role and mandate for DPO. °The expert panel agreed that any activities in the field of desertification control in the region should be closely linked to the UNCCD and especially to the Regional Implementation Annex for Asia.
- In view of this, it was recognized that there is a need to confirm DESCONAP as a regional instrument for the implementation of UNCCD.
- The Panel noted with appreciation the offer of the Government of the Islamic Republic of Iran to host a high level meeting in 1996 in Tehran to discuss the above issues in compliance with ESCAP Commission Resolution 51/11.
- The meeting of the DESCONAP members, in consultation with the Asia Group should further advise on the next steps necessary for strengthening the network and enhancing the regional implementation of UNCCD including convening the high level meeting later in 1996 either separately or in conjunction with other meetings which will be organized in the context of UNCCD.
- The meeting further noted that ESCAP and UNEP confirmed their commitment to support DESCONAP within existing financial resources.

Training Workshop on the Concept, Establishment and Multipurpose Application of the SOTER Database in the Middle Eastern Region

Damascus, Syria, 23-29 December 1995

Executive summary

The fourth regional SOTER pilot project involves the establishment of a Soils and Terrain Database for the Interpretation of Sustainable Land Use Systems, and the Status and Trends of Soils and Land Resources in the Middle East (MESOTER). The project commenced in October 1994 and was implemented by the Arab Centre for the Stud of Arid Zones and Dry Lands (ACSAD) in association with ISRIC and the Departments of Soils in Jordan and the Syrian Arab Republic. The aim of the project was to strengthen capacity and expertise in the region to compile and update a soils and land resources database, which would then be used to interpret information on land use planning and monitoring of land resources through on-the-job-training as well as institutional support.

The main objectives of the training workshop were:

- To provide senior government officials from the region with information on the SOTER concept and SOTER methodology;

- To demonstrate to the participants the establishment of SOTER databases giving the examples of Jordan, the Syrian Arab Republic and Kenya.
- To demonstrate to the participants the multipurpose applicability of the SOTER databases for land use planning, land evaluation, assessments of soil degradation, including water and wind erosion, and soil salinization/ alkalinization;
- To conceptualize future SOTER activities in the Middle East.

Sixteen soil scientists and GIS experts from eight countries namely: Egypt, Jordan, Iraq, Lebanon, the Libyan Arab Jamahiriya, Oman, Sudan and the Syrian Arab Republic plus observers from ACSAD and UNEP participated in the workshop. The Workshop programme included lectures and discussions, a three-day field tour and a plenary session to discuss future activities. It was agreed in the plenary session that ACSAD in Damascus, will be the "centre of excellence" for the training and demonstration of SOTER methodology for the Middle East and West Asia and that invitations be extended, to the relevant countries in those regions to participate in future training workshops whenever resources were available.

The participants of the Workshop expressed their gratitude to UNEP and ACSAD for the opportunity to get acquainted with SOTER, and requested the two organizations to do their utmost to:

- Assist their countries in acquiring SOTER technology by training personnel and through institutional strengthening;
- To extend SOTER technology to other countries in the region for the purpose of harmonizing soil and terrain databases in the region;
- To translate the SOTER Procedures Manual into Arabic.

BOOK REVIEW

Biota and Environment of the Kalmuck Republic

Edited by Dr S. Zonn and Dr V. Neronov

This publication consists of 13 original articles on desertification/land degradation in the Kalmuck Republic of the Russian Federation.

Consideration is given to a number of ecological problems which have arisen in the Republic within the last 70 years. Special attention is paid to the degradation/desertification of pastureland, the salinization of soil, and the nature of ground water due to the development of irrigation and the rise of the Caspian Sea as well as the problem of drinking water supplies.

Our Planet

Our Planet, UNEP's bi-monthly magazine for sustainable development, is written for the general public and aims to explain environmental and development issues in a reader-friendly and accessible format. Each issue is dedicated to a specific theme (biodiversity, coastal ecosystems, ozone, etc) and includes news and information from each of UNEP's regional offices throughout the world.

In 1994, *Our Planet* dedicated volume, 6, No.5 to the issue of desertification, including the historical, social, economic and political perspectives. Of particular interest were articles from Franklin Cardy, the director of DEDC/PAC, Bo Kjellén, the Chair of the Intergovernmental Negotiating Committee for the Elaboration of a Convention to Combat Desertification and other renowned experts in the field (see table of contents).

Proceedings of an International Training Course, *"Reclamation and Management of Saline Irrigated Soils"* held in Volgograd, Russia, October 1994.

Edited by Pavlovsky Ye. S., Russian Academy of Agricultural Sciences, Moscow, CiP, 229p, 1995 in Russian.

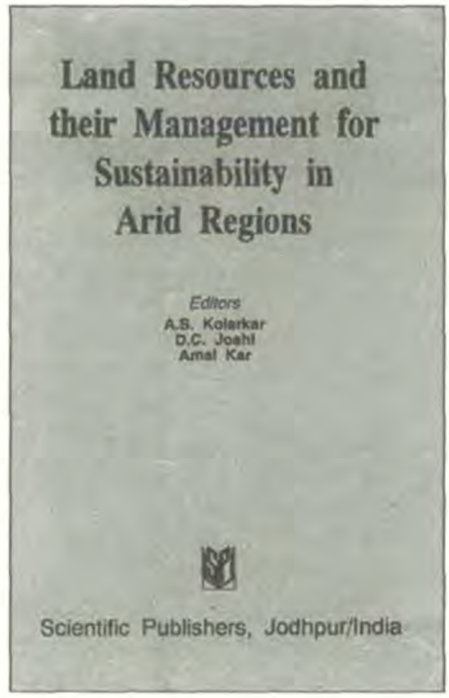
This publication attempts to describe specific problems and their solutions on the reclamation and management of saline soils in arid and semi-arid regions. It is a useful guide for scientific institutions, individual researchers and universities as it raises awareness about the reclamation of salt-affected soils.

Available from CiP.

Fax: (095) 165 5208, Ms. M. Klimova.

Land Resources and their Management for Sustainability in Arid Regions

Editors
A.S Kolarkar, D.C. Joshi, Amal Kar
Scientific Publishers, Jodhpur, India



Land use for sustainable productivity requires an environmentally sound solution so that the resource base is maintained or enhanced for future generations. The mounting pressure of human and animal populations and increased crop/biomass production through modern technologies have not been sustained by the land resources of arid regions. Concerned about this mounting pressure on the scarce resources of the arid lands, UNESCO sponsored a training programme on "Land Resources and their Management for Sustainability in Arid Regions" at CAZRI. This compendium is an outcome of that training programme.

The contents of the book include the concept of sustainability, land resource constraints in the arid regions, their vulnerability to degradation, and sustainable management of land resources through agriculture, horticulture, silviculture and pasture development.

NEWS OF INTEREST

Request for Articles and Photographs

The editorial board of the Desertification Control Bulletin is seeking photographs and articles for publication in the magazine. In particular, the editorial board is interested in receiving articles describing success stories in controlling dryland degradation and desertification, follow-up in the implementation of the United Nations Convention to Combat Desertification and NGO activities in the field of desertification control in all regions of the world, particularly Africa.

The technical advisor is also seeking photographic submissions for use on the cover of the Desertification Control Bulletin. Photographs should be colour transparencies of subjects related to desertification, land degradation, humans, animals, structures affected by desertification, reclamation of degraded lands, etc. Please include a brief caption giving a description of the subject, place and country name, date of photograph and name of the photographer.

All contributions should be sent to:

Mr. Leonid Kroumkatchev
Technical Advisor
Desertification Control Bulletin
UNEP DEDC/PAC
P.O. Box 30552
Nairobi
Kenya
Tel:254-2-623 266
Fax:254-2-215 615/623 284
Email:Leonid.Kroumkatchev@unep.no

For more information regarding manuscript preparation, please see page ii of this issue of *Desertification Control Bulletin*

Call for the Submission of Success Stories in Land Degradation/ Desertification Control in Drylands for the Saving the Drylands Award 1998

The front line in the battle against desertification consists of farmers, often women and children, struggling to scrape a living from a hostile environment. Over centuries and throughout most of the drylands these farmers have gained the skills to do this successfully and the physical challenge in normal times is something they can handle. Indeed there are unrecognized skills of sustainable management, adaptability, risk assessment and insurance that have been developed in the drylands that need wider recognition and dissemination.

Experience has shown that where communities participate fully in all development phases, success is achievable and in a sustainable manner. Projects or activities of this nature which have contributed substantially to the control of land degradation and desertification are few in number, compared to the failures, but they deserve more attention than has been the case so far. These *successes* need to be better publicized so that the positive experiences will show the world community that land degradation and desertification can be controlled. They will also serve as lessons for those projects in the process of being designed and implemented. A mood of confidence needs to be created, which recognises that degraded lands can be, and have been, rehabilitated and made sustainably productive.

With this in mind, UNEP decided to solicit the submission of success stories in desertification control. A success story is an activity that directly and substantially contributes to the prevention of dryland degradation or to the reclamation of degraded land using appropriate resources in a cost-effective manner. It addresses not only the biophysical but also the socio-cultural-economic issues in all their development stages, thus ensuring long-term sustainability. The drylands were felt to be so important that it was decided to create a specific Award *Saving the Drylands* to recognise outstanding activities.

In 1994 ten case studies amongst

several submitted to UNEP for consideration for the Award were short-listed for on-site evaluation. Of these, eight (Australia, Senegal (2), Namibia, India, Pakistan and China (2) were finally selected as outstandingly successful and received the 1995 "Saving the Drylands" Award. This year, two projects, one in Sudan and one in India, were the recipients of the 1996 "Saving the Drylands" Award.

It is our hope that through this programme of recognizing outstanding achievements, more people will be encouraged to send success stories to UNEP for evaluation and dissemination. We will then be able to share the lessons learned as well as successful practices. We believe that this in turn will help lead improve desertification control.

For the 1998 nominations for the Award please send a one page summary of the project/acivity you are proposing with the following information in the given order: 1. Name of Project 2. Country 3. Location in country 4. Number of people involved 5. Area (sq km) covered by the project 6. Cost of Project (US $ equiv.) 7. Source of Funds 8. Project Period (years) 9. Problems 10. Solutions 11. Results/ Impact 12. Why the project is a success 13. Names and addresses of three referees outside the project 14. Contact person.

In submitting the above project summary please ensure that some climatic and physical information (climatic zone, rainfall, temperature, major vegetation and soil types) is included in point 8. Extra supporting information on the above points may be submitted separately and may also include the following: feasibility studies; community perticipation; need orientation adaptability, replicability and cost effectiveness; extent of government collaboration; major constraints encountered in achieving success; etc.

Please submit your success stories for the 1998 "Saving the Dryland" Award on or before 30 April 1997. However, success stories submitted to UNEP by November 1996 may be considered for the 1997 Award.

For further information and for submitting your success stories write to:

Coordinator, Success Story Initiative
UNEP, DEDC/PAC
P.O Box 30052,
Nairobi
Fax: 254-2-623284
Tel: 254-2-623261
E-mail:
elizabeth.migongobake@unep.org

Announcement and Call for Papers and Posters for an International Symposium and Workshop

"Combating Desertification: Connecting Science with Community Action"

May 12-16, 1997 Tucson, Arizona
optional Training Package: May 17-23, 1997

Sponsored by the United States Department of the Interior Bureau of Land Management and International Arid Lands Consortium in collaboration with The University of Arizona USDA-Agricultural Research Service U.S. Environmental Protection Agency Centro de Investigaciones Sobre Desertificacion

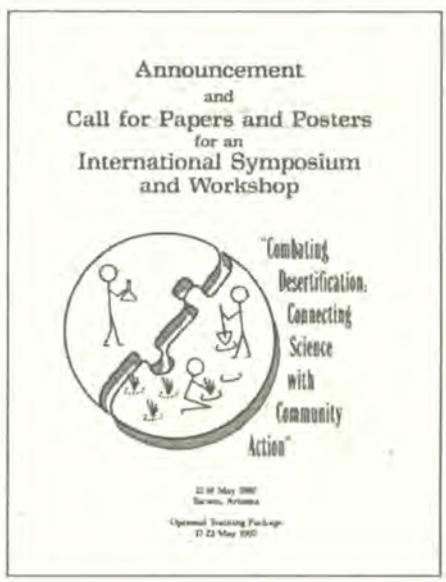
Supported by

European Society for Soil Conservation
objective

The objective of this Symposium and Workshop is to provide for a significant exchange of ideas between (1) the developers of science and technology related to combating desertification, and (2) the community-level decision makers who must deal with the problems of desertification and drought on a day-to-day basis.

Symposium and Workshop Topics

- Stressors, indicators and processes related to land degradation operating at local to global scales.
- Effective techniques for monitoring and assessing desertification.
- Lessons learned at the community level in combating desertification and mitigating the effects of drought.
- Socio-economic/human dimensions of desertification and its control. Linking science to



community action through knowledge sharing.
- Motivation techniques proven successful at various (individual, community, national, subregional, regional) levels that create the environment and support for effective sustainable local action.

Call for Papers and Posters

Scientists, land managers, non-governmental organizations and men and women working at the local level (as well as those developing techniques and strategies) to combat desertification are invited to participate.

Individuals interested in presenting a paper or poster at the Symposium should contact:

Mr. Beaumont C. McClure
Bureau of Land Management
Arizona State Office
P.O. Box 16563
Phoenix, Arizona 85011-6563
Telephone: 602-650-0206 Telefax: 602-650-0398
E-Mail (Internet): bmcclure@attmail.com

Abstracts must be received by 1 April 1996, to be considered for inclusion in the programme.

Registration Information

The Symposium and Workshop will be held from 12 to 16 May 1997 at The Doubletree Hotel, 445 South Alvernon Way, Tucson, Arizona, U.S.A. An optional training package is being developed in conjunction with the Symposium and Workshop, which may include travel to Sierra Vista and Safford, Arizona and Las Cruces, New Mexico through May 23. Registration information will be distributed by October 1996.

International Training Workshop on Soil and Water Conservation and Dryland Farming

Yangling, China.
Sept. 9 - 28, 1996

Introduction

International Training Course/Workshops are annual events in china sponsored by the State Science and Technology Commission of China (SSTCC) as part of its International Science and Technology Exchange Programme.

The Workshop on Soil and Water Conservation and Dryland Farming in 1996 will be arranged by the Department of International Science and Technology Cooperation, SSTCC, in collaboration with the Wugong Agricultural Science Research Center.

Main Objectives

The main purposes of this Workshop are as follows:

- To present information and experience on soil and water conservation and dryland farming;
- To provide opportunities for on site observation of the spectacular land forms on the loess plateau;
- To visit soil and water conservation and dryland farming projects implemented in this region;
- To discuss future strategies for sustainable agricultural production in the dryland region;
- To promote international cooperation and academic exchange between China and other developing countries.

Duration

From September 9 to 28 1996 (20 days)
Host and Location
Wugong Agricultural Science Research Center
Yangling, 712100
Shaanxi Province
P.R. China
Telephone: (0910) 7012371
Fax: (0910) 7012377; (0910) 7012570

Working Language

English

The Jordanian Society for Desertification Control

The Jordanian Society for Desertification Control and Badia Development ([JSDCBD] Arid and Semi-arid regions), has started its activities.

JSDCBD was established in May 1990, based on the recommendations of the permanent committee for desertification control adopted by the League of Arab Countries. JSDCBD is a non-profit, non-government society, specializing in studies and research related to desertification and its proposed solution.

JSDCBD focuses on media programmes to raise public awareness about desertification and seeks support for its programmes.

JSDCBD's Scientific Committee, headed by Dr Mohammed Shakhatreh, desertification control expert, is responsible for preparing studies and research programmes related to the objectives and activities of the Society.

This Committee is preparing documents on desertification control for students and high level specialized technicians, in addition to its usual programmes.

Our Society as a regional body is looking for close collaboration with your organization on matters of common interest and awaits your contribution to achieve its objectives.

Status and Distribution of Wild Bactrian Camels, *Camelus bactrianus ferus*, in the Xinjiang Uygur Autonomous Region and Gansu Province in the People's Republic of China

John Hare

At the invitation of the Xiniiang Environmental Protection Bureau, and with sponsorship from the United Nations Environment Programme (UNEP) and Fauna and Flora International, an eight-man expedition undertook a detailed survey between 13 April and 28 May, 1995, of the status and distribution of wild Bactrian camels, *Camelus bactrianus ferus*, in the Xinjiang Uygur Autonomous Region and Gansu Province in the People's Republic of China, the last known refuges of the wild Bactrian camel in China. The survey revealed that the wild camel is highly endangered with estimated total numbers worldwide not in excess of 800.

Introduction

The Bactrian camel

Three great deserts, the Gobi, the Desert of Lop and the Taklamakan desert sprawl across the map of Central Asia. The enormous space which they occupy, the Taklamakan alone is seven times the size of Britain, never touches a coast and this remoteness from any seaboard, reduces the amount of rainfall in all three deserts to a minimum. Although they are not totally without rivers or lakes, these cannot drain into a sea and the watercourses that flow down from melting snowfields disappear in salt-marshes or into oceans of sand. The rapidly fluctuating temperature extremes generate fierce winds which sweep across the desert blotting out the sun in dense sand storms that blast with a ferocity that can strip the paint off a vehicle in ten minutes.

This has resulted in vast areas that can sustain no human life at all and in which for centuries the migratory track from one oasis to another marked the only trail on which man could exist. Over the years, these deserts have advanced slowly but steadily, choking

Photo: John Hare

Wild Bactrian camel.

lakes and river-beds and turning chains of mountains into dunes of sand. All this combines to make these three deserts the most desolate places on earth.

Yet in these three forbidding and hostile wastelands, the last remaining herds of the wild Bactrian camel, *Camelus bactrianus ferus*, struggle to exist. They have been forced into this inhospitable terrain by the activities of man and in these harsh surroundings they are still, for the most part, under threat from hunting, legal and illegal gold and iron-ore mining, and the recent discovery of oil. The wild Bactrian camel is listed by IUCN as 'vulnerable', yet there is no doubt that it is now 'highly endangered'.

The survey

In August 1993 a survey was made of the wild Bactrian camel in the Great Gobi National Park A in Mongolia by the Joint Russian-Mongolian Scientific Expedition. The survey revealed that the number of oases where the camel could obtain a reliable water supply had decreased since 1982 from approximately 15 to eight on account of a succession of severe droughts. The camel gives birth in oases during the coldest time of year, (December/January), and wolves congregate near these diminishing water reserves and kill the newly-born. The survey estimated that the percentage of surviving young was only 4.25 per cent of the total of approximately 350 wild camels in the Mongolian Gobi. A survival percentage of 10 per cent to 15 per cent is probably needed to maintain the current population.

The Mongolians had captured thirteen wild camels which grazed with domestic Bactrian camels near the Great Gobi National Park A. In December 1993, an expert camel handler was sent under UNDP sponsorship from Kenya to Mongolia to supervise a breeding programme for these captive wild camels. This expert returned to Mongolia in December 1994 but the programme, which started satisfactorily, has subsequently been closed down due to withdrawal of UNDP funding. There are only seven other wild camels in captivity, all of them in China.

In September 1994, I presented a paper on the status of the wild camel in Ulaan Baator to a Conference on Sustainable Development in Central Asia sponsored by the European Union. The main thrust of the paper was to seek permission from the Chinese authorities to allow a visit to be made to Xinjiang Uygur Autonomous Region and Gansu Province to try to establish the numbers of wild camels. There was no recent information available, the last detailed surveys having been made in 1981 and 1985 by Professors Gu and Gao. As a result of this plea, a survey to Xinjiang Uygur Autonomous Region and Gansu Province took place during March, April and June, 1995.

The survey areas

The first survey (a) took place in the area north-west, north-east, east and south of the dried up lake-bed of Lop Nur. This covered the southern slopes of the Kuruk Tagh mountains, the Gashun Gobi and the Aqike valley north of the Kum Tagh sand dunes. This area is extremely important as it is the only area where the wild camel does not come into contact with domestic camels. Hybridization has therefore not taken place and the camel strain is considered to be genetically pure. The area is extremely barren and remote and until recent years there was little human impact. The Aqike valley, south of Lop Nur, was considered by the Swedish explorer, Sven Hedin to be the heartland of the wild camel. It has good vegetation cover and is protected to the south by the Kum Tagh sand dunes.In 1981 Professors Gu and Gao estimated that there were 117-147 camels in the valley and 'up to 200' in the Lop Nur region.

The second survey (b) was made in the area directly to the south of the Chinese/Mongolia border and the Mongolian Great Gobi National Park A . Camels from the National Park wander across the international border and the fifteen kilometre buffer zone into this section of Gansu Province in China. The Dacoatan spring in Gansu Province is a favoured area for the camel and lies 80 km. due south of the Atas Ula mountain range, one of the principal habitats of the camel in the Mongolian Great Gobi National Park A. In 1990, the Chinese Government lifted a ban on mining (mainly gold mining) in this area. As a consequence, 100 km. from the border area there is much mining activity both legal and illegal. Even the military own and operate a mine. The miners use potassium cyanide, a highly toxic, illegal chemical, which contaminates grazing over a considerable distance.

The third survey (c) was made along the northern slopes of the Aijin Shan (Altun Tagh) mountains from Ananba to Ruoqiang (Charkhlik), through the Desert of Lop to the barrier formed by the southern slopes of the Kum Tagh sand dunes. The Aljin Shan mountains contain many valleys. In , summer and autumn water flows through them into the hostile Desert of Lop and towards the formidable barrier of sand dunes, the Kum Tagh, which run from east to west for 300 km. south of Lop Nur between Milan and Dun Huang. The Ananba Nature Reserve established by Gansu Province in 1982 and covering 3,900 km. offers limited protection for the wild camel in this area but there is a shortage of funds and low morale.

The fourth survey (d) was made into the Taklamakan desert, through the Tarim river basin south of Luntai'and from there both to the east and to the west of the new north-south highway which leads to the oil camp terminal, 800 km. south of Luntai. This highway, which will shortly link Luntai with Khotan, runs down the 84 .15' parallel. There is much heavy vehicle activity on this road which bisects the camels' habitat in the southern reaches of the Tarim basin.

Methods

The eight members of the expedition comprised the leader, Professor Yuan Guoying, from Xinjiang Environmental Protection Bureau, Li Hongxh, senior botanist from the same Bureau, Yuan Lei, the Professor's son, Sung Yidong, the jeep driver, Xiao Kegang, the lorry driver, Zhao Zhigang, my interpreter and Mr. Zhao Ziyun, the guide, known all over Xinjiang Province and greatly respected by Chinese and Uygur alike. He has a detailed knowledge of the area having visited it since 1974, initially as a camel hunter. He was only able to accompany us during the survey in area (a). The expedition covered over 5,500 km. Temperatures varied from -7 *C at night to + 30 *C during the day. On two occasions, once in survey area (a) and the other in survey area (c), sand-storms occurred with winds in excess of gale force 7. The expedition travelled in two vehicles; a jeep and a six-wheel supply truck. There was no radio communication and surveys of the wild camels were carried out by jeep and on foot.

In survey area (a), the former heartiand of the wild camel and the one area that is free from cross-breeding with domestic stock, no camels were sighted. The total survey of this area from Tikar to Yunmenquan covered 1400 km. and took twelve days. We walked up three valleys in the Kuruk Tagh mountains and in these three valleys found recent evidence of both young and adult camels. All the springs in the survey area are saline and we visited seven. Out of the seven there were hunters' hides near four. Traditionally, the Uygur people of Tikar hunt the camel and although this is an illegal activity it still continues. Three water sources near the northern shores of Lop Nur and known by Mr. Zhao to be watering points for wild camels in the early nineteeneighties, were now dry. Between the Kuruk Tagh mountains and Lop Nur we came across many well-used migratory tracks of the camel and found evidence in three separate areas which indicated where groups of up to seven had rested. In the Aqike valley we found approximately year-old camel droppings and this indicated that they were abandoning this area. Legal and illegal gold miners were excavating for gold at four separate sites and near one such site, a saline spring, we found the remains of a dead camel as well as a hunters' hide. We encountered two gold miners' trucks and were told by one of the drivers that in 1994 a wild camel had drowned in a pit that had been dug for the purpose of processing gold.

In survey area (b) we made two surveys on foot to the area overlooking the Dacoatan spring. We were prevented by the military from approaching this spring which runs from east to west for 100 km. along the border buffer zone. Mongolian herdsmen Batuer and Minjur confirmed that it is a refuge for wild camels from Mongolia and in 1995 they saw 50 camels there on two separate occasions. In the same year in the Kushui area of the Dacoatan spring there was also a sighting on two separate occasions of three of the highly endangered Gobi bears, *Ursus gobiensis*, whose world-wide population is not thought to exceed 35. These sightings were made by Mongolian herdsman Batuer and an unnamed herdsman. Miners from Xinjiang and Gansu had been fighting in the area over gold-mining rights and a battle with shot-guns had taken place 90 km. south of the Dacoatan spring two days before our arrival. We came across a sign warning herdsmen not to graze livestock 80 km. south of the spring on account of potassium cyanide contamination. The distance covered on foot and by jeep in the area exceeded 700 km.

In survey area (c) we covered 800 km. and drove along the abandoned, dilapidated road from Dun Huang to Ruoqiang. We visited Ananba and camped for five days in the foothills of the Aljin Shan mountains near the Lapeiquan spring and for two days at the head of the valley at Hongliugou. During our stay near Lapeiquan we made five separate surveys on foot and by jeep in the direction of the Kum Tagh mountain range and observed a total of 49 wild camels including one lone bull camel in a valley of the Aljin Shan and one female camel with a calf (estimated to be seven hours old) in the Kum Tagh. We saw one additional bull camel in the region of Hongliugou.

We interviewed third generation Kazak herdsman Aljun who gave us the following information: (1) he believed that there were up to 500 wild camels in the Aljin Shan mountain area; (2) the most common predators were jackals, wolves and snow leopards; (3) during the mating season a bull camel will sometimes pen females in a valley to prevent them from leaving until after a successful mating has taken place.; (4) a female camel can reproduce at four years and gives birth once every two years, she leaves the group for 10 days at parturition; (5) a bull camel can mate at two years but is usually prevented from doing so by a dominant bull; (6) a wild camel can live up to 40 years, go for 20 days without water and can dig to a depth of half a metre to find water.; (7) in 1980 a geological survey team shot 40 wild camels for food. The wild camels mate during November/December and March/April/May; and (8) they will not mate during periods of extreme cold.

In survey area (d) we crossed through the lower reaches of the Tarim river and made three surveys on foot into the Taklamakan desert to the east and west of the new road to the oil camp. These three surveys covered 30 km.

In addition we drove 800 km. to the oil camp and 800 km back to Luntai.

Results

In survey area (a) we sighted no camels although we saw clear evidence of their existence and their long lines of migration from one water point to another. There was recent evidence of their occupying the southern valleys of the Kuruk Tagh. We discovered three water holes near Lop Nur that were dry. We found clear evidence of extensive hunting of wild camels, (three adult skeletons and one young), and goitered gazelle,*Gaze//e subgutturosa*, (six adult remains). The hunters' vehicle and donkey cart tracks showed that they did not just come from Tikar, where there is a tradition of camel hunting, but also from Hami where there is no such tradition. Mr. Zhao said that this was a recent development and that hunting was on the increase. We found evidence of two illegal gold mines in the Aqike in addition to two legal gold mines. This mining puts great pressure on the 'heartiand' habitat of the camel and the camels appear to be abandoning the Aqike valley.

In survey area (b) in discussion with herdsmen Batuer and Minjur we learnt that the Dacoatan spring area is favoured by wild camels that cross the border from Mongolia. On 19 April 1995 herdsman Minjur saw 40-50 camels near the spring. In February 1995 three bull camels in rut came to Minjur's encampment 70 km. from the border to try to mate his domestic female camels. Gold mining activity, both legal and illegal, inter-provincial fighting and the use of potassium cyanide in the mining process puts great pressure on the wild camel habitat south of the Dacoatan spring.

In survey area (c) we saw 46 wild camels between the Aljin Shan'mountains (Lapeiquan) and the Kum Tagh sand dunes. Of these 19 were positively identified as females and 12 as young. In addition we saw one female at close quarters in the Kum Tagh with a seven-hour-old-calf and two solitary bulls in valleys near Lapeiquan and Hongliugou. Total sightings - 50; confirmed young 13. We saw evidence of hybrid stock in five separate groups of domestic camels.

In survey area (d) We found two old skeletons of wild camels of indeterminate sex and age in the lower reaches of the Tarim River. Professor Yuan Guoying photographed a camel from the new highway in March 1995. We saw evidence of the highway cutting through migratory routes of the camels.

Conclusions

Our estimates of wild camels that survive in each of the four areas is based on the personal knowledge of Mr. Zhao, discussions with herdsmen and our own observations. We concluded that 80-100 remain in survey area (a) 350-400 in survey area (b). This latter figure includes those in the Mongolian Great Gobi Park A and is based on a survey made by the author with the joint Russian-Mongolian expedition and Dr. George Schaller to the Great Gobi National Park A in August 1993. 250-300 in survey area (c), the Aljin Shan, and 50-80 in survey area (d), the Taklamakan desert.

Total numbers: minimum 730, maximum 880.

Discussion

IUCN categorise the wild camel as vulnerable. It is highly endangered.

In survey area (a) the population has declined by almost 75% since the surveys made by Professors Gu and Gao in 1985. We therefore propose that an **International Protection Area for the Wild Camel** is established without delay. This Protection Area would prevent the illegal impact of human activity within the area from rendering the only genetically-pure strain of wild camel extinct and make a significant contribution to biodiversity protection.

To fulfil this proposal, we urge that the Protection Area's range is 89 00' - 93 OO'E and 39 30' - 41 45'N (excluding the ancient city of Lou Lan) This would provide a total area of 11,500 sq. km. in Xinjiang and 2,000 sq. km. in Gansu. Except for four gold mines (two illegal) two salt mines and one lead-zinc mine there are no other mining activities in the area. It would be situated in the southern part of Shanshan County and Hami County, the northern part of Ruoqiang County and the eastern part of Yuli County. Once established in law, there would be a headquarters at Shanshan (five-eight staff), with substations at Tikar, Nanhu and Yumenquan, each with three staff. This administration would: (1) set up check points; (2) patrol the area; (3) undertake local public awareness programmes; (4) scientific research; (5) provide additional water points for the camels; and (6) erect boundary signs. The estimate for the project is $US 750,000 and full details of the budget can be sent on request. The proposed Protection Area has already received the support of the National Environment Protection Agency of China, who have indicated that they will pay the recurrent costs for ten years if the necessary capital funding can be found. The Xinjiang Environmental Protection Bureau and the Bayan Golan Mongolian Autonomous Prefecture have also offered their full support. We are actively seeking support from Ruoqiang, Shanshan, Hami and Yuli County Authorities to stop illegal hunting and illegal mining within the area. We propose paying compensation to Ruoqiang County to close down the legally established mines.

We feel that unless this immediate action is taken, the last geneticallypure strain of wild camel could be extinct within five years.

Survey area (b) needs strict controls in the Dacoatan spring area. We are endeavouring to arrange contact with the appropriate authorities in China and Mongolia so that full camel protection can be made in the border buffer zone. We are also recommending the strict ban on potassium cyanide, the illegal substance used in the gold-mining process.

In survey area (c) we recommend a strengthening, through the provision of adequate finance, of the Ananba Protection Area and that the potential threat of mining in the Aljin Shan mountains be closely monitored.

In survey area (d) we feel that little can be done for the wild camel on account of the intensive oil extraction activities and the development of the new highway.

References

Gu, J-H and Gao, X. 1985. *The Distribution of the Wild CameL* Chinese Academy of Sciences.

Hedin, S. 1940. *The Wandering Lake.* George Routledge and Sons, London.

Farewell

It is with much regret that DEDC/PAC bids farewell to Mr. Moustapha Sar, Senior Programme Officer, who retired at the end of May 1996. Mr. Sar has been working with UNEP since August 1992 and was particularly involved in the African Ministerial Conference on the Environment and Northern African projects. He holds a PhD in applied Geography from the University of Strasbourg, France.

Mr. Sar started his professional career as National Director of Land Management and Physical Planning and Development in Senegal, a post he held until 1975. Subsequently he was in charge of the National Office of Town and Country Planning and then was appointed as Technical Advisor to the Minister for Planning and Cooperation on issues concerning rural development, land management, implementation of land reform, drought, desertification control and natural resources management until 1982.

He was the General Director and Chairman of the Organization for Development of the Petite Côte until 1989.

Prior to joining UNEP, Mr. Sar was the Technical Advisor to the Minister for Planning and Cooperation for the Government of Senegal.

Mr Sar is married with six children.

He and his family have returned to live in their home country, Senegal.

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 adapted by the United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil, in June 1992.

The United Nations Convention to Combat Desertification was formally adopted on 17 June 1994 and opened for signature in Paris on 14 October 1994. This Convention is notable for its innovative approach in recognizing the physical, biological and socio-economic aspects of desertification; the importance of redirecting technology transfer so that it is demand driven; and the involvement of local populations in the development of national action programmes. The Convention currently has 115 signatories and has been ratified by 25 countries. The Convention will enter into force 90 days after the receipt of the 50th instrument of ratification.

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