

# Combating Desertification

## Rehabilitation of Degraded Drylands and Biosphere Reserves

Proceedings of the

International Workshop

**ALEPPO  
SYRIA**

2 May to

3 May 2002



**UNESCO-MAB Drylands Series    No. 2**

# **INTERNATIONAL WORKSHOP ON COMBATING DESERTIFICATION**

**ALEPPO, SYRIA**

**2–3 May 2002**

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United Nations University (UNU)

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**Rehabilitation of Degraded Drylands  
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**Proceedings**

Volume Editors: Cathy Lee, Thomas Schaaf

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United Nations Educational, Scientific and  
Cultural Organization (UNESCO)

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# Preface

The 1969 to 1973 drought in the African Sahel helped focus world attention on desertification. Ever since, misconceptions have arisen from the poorly understood processes of desertification, which are often wrongly attributed solely to droughts. Droughts are common in arid and semi-arid lands, but it is the deadly combination of continued land abuse during periods of deficient rainfall that results in unproductive land, and ultimately desertification. Well-managed land will recover from droughts with minimal adverse effects when the rains return. However, understanding the intricate relationship between climate change and poor land-use practices by enhancing knowledge on desertification process is essential. Just as is determining actions needed to halt its progression — essential if we wish to halt the unrelenting degradation of natural resources that threatens our common future.

Workshops such as took place in Aleppo bring together scientists and experts working in this field to share their experiences so as to improve our knowledge and practices to combat desertification. The World Network of Biosphere Reserves has a significant role to play, as there are currently 425 biosphere reserves worldwide in 95 countries, with 47 biosphere reserves being largely arid and semi-arid ecosystems.

The contributions in this volume constitute the second publication of the UNESCO-MAB Drylands Series and stem from the International Workshop on Desertification: Rehabilitation of Degraded Drylands and Biosphere Reserves, which took place at the ICARDA Headquarters in Aleppo (Syrian Arab Republic) from 2–3 May, 2002. The workshop was organized by UNESCO's Man and the Biosphere (MAB) Programme in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) and the United Nations University (UNU). The success of the workshop was assured by the representation of twelve countries and related United Nations agencies and international organizations.

The theme of the workshop was the establishment of capacity for the rehabilitation of degraded drylands, using site-specific examples of biosphere reserves to assess potential natural vegetation and viable wildlife populations in drylands. With almost half of the global land surface, equal to 6.45 billion hectares, made up of drylands, the importance of these sites is ever more apparent. The workshop was also an occasion to begin preliminary discussions on the long-term project entitled "Sustainable Management of Marginal Drylands". This project will adopt a systematic approach for the long-term *in situ* conservation of natural resources by involving and supporting local populations in their efforts to use natural resources sustainably. The project also seeks to apply scientific methods for improved management of marginal drylands.

Combating desertification by rehabilitating degraded lands can be done successfully, using existing, often traditional techniques. It is for this reason that workshops such as these are paramount to providing and sharing practical and inexpensive solutions to common problems. The conservation of biological diversity is key to combating desertification. While much focus is placed on tropical forests, the often high rate of endemism, the wide range of species adaptations, and the highly heterogeneous landscapes of drylands make them just as important — the forgotten part of biodiversity!

UNESCO-MAB, as principal organizer of the workshop, and on behalf of all the workshop participants, wishes to thank ICARDA for the tremendous support and excellent organisation of the workshop. I also wish to extend my warm thanks for the contribution made by the all the participants and international organizations who took part in the workshop.



Peter Bridgewater  
Secretary  
Man and Biosphere Programme  
UNESCO

# 1 ICARDA'S Experience in the Rehabilitation of Degraded Drylands in Central and Western Asia and Northern Africa

*Professor Dr Adel El Beltagy, Director General, International Center for Agricultural Research In the Dry Areas (ICARDA), Aleppo, Syria*

The world is in the midst of an ecological transition that is affecting our planet and therefore our lives in many different ways. Desertification is one of the main challenges of this ecological transition. Can we control and even reverse desertification in the new millennium, with renewed hope for improved living conditions for present and future generations? I believe we can.

The total population in the world's dry areas is over one billion people, of which approximately 696 million live on less than two American dollars a day. Seven out of ten of the world's poorest countries are located in these dry areas. Desertification and soil degradation are severe problems in these regions, problems exacerbated by low and irregular rainfall.

While ICARDA's mandate encompasses the dry areas of the entire world, our research focuses on the Central and West Asian and North African (CWANA) region, which covers some 1.7 billion hectares and is where the majority of dry-area countries are located. Of the 34 million hectares of irrigated cropland in CWANA, 11.3 million hectares, or 33 percent, suffers from some form of degradation. Fifty million hectares (68 percent) of the 73 million hectares of rained crop land is estimated to be degraded, and of the rangelands as much as 85 percent is degraded. This translates into an estimated 45 percent of the area being subjected to some form of desertification. Precise estimates on the extent of land degradation and, more importantly, its impact on production, are lacking and require research. Most crop production in the region is obtained from irrigated land: for example, approximately 80 percent of crop production in Afghanistan is from irrigated land. However, these lands are prone to salinization. Hot spots for salinization include Egypt, the Nile Valley, the Tigris and Euphrates river basins, and areas surrounding the Aral Sea.

Soils in the drylands contain low organic matter with a carbon content of only 0.1 to 0.5 percent. Such soils are very vulnerable to degradation through physical erosion and to chemical and biological degradation. Particularly careful management is needed for these

soils to remain suitable for the agricultural uses they are put to at present, which includes grazing livestock on extensive pastures.

The situation regarding water availability is alarming. The West Asian and North African (WANA) region is currently lacking in water resources and the situation is likely to worsen in the future. We must pay increased attention to water conservation to prevent such a situation. In addition to the overall scarcity of water are problems of water quality and productivity.

Degradation of land and water is a major threat to food security in the region. Together with higher-than-average population growth rates (up to 3.6 percent), this translates into a projected food gap for 2020 of some 114 million tonnes of grain in twenty-seven countries, at an estimated cost of fourteen billion dollars. The poor spend a major part of their income on food, it is therefore important to increase their incomes to well above the poverty line.

The CWANA region contains three of the eight important centres of biodiversity of crop species identified and described by Russian botanist N.I. Vavilov. But when land becomes degraded, habitats for plant species also disappear — with the result that there is an ever-increasing threat to the rich sources of biodiversity in the region, for both plant and animal species. This process highlights the intimate relationship that exists between human beings, natural resources, and food. To have a meaningful impact on the lives of people living in dry areas, these three aspects must be fully integrated within a multidisciplinary approach.

ICARDA is one of sixteen international agricultural research centres united under the umbrella of the Consultative Group on International Agricultural Research, CGIAR. The CGIAR is an international group of donor agencies, eminent agricultural scientists and institutional administrators from both developing and industrialized countries who guide and support its work. CGIAR's mission is to promote sustainable agriculture to alleviate poverty and hunger and to achieve food security in developing countries.

ICARDA's general mandate is to promote more productive agricultural practices in developing countries with dry, subtropical or temperate climates, through research and training activities. ICARDA specifically aims to improve the welfare of people living in the dry areas of the poorest regions in the developing world. Agriculture in such dry-area environments, which are harsh, stressful and variable, faces more complex challenges than in areas with adequate rainfall. Through research activities and the provision of training, ICARDA aims to increase agricultural productivity in these areas and to raise the nutritional quality of the food produced to higher, sustainable, levels, while preventing further degradation of natural resources and ensuring environmental protection.

ICARDA's headquarters are in the heart of the low-rainfall zone in northwestern Syria, from where it is well placed to serve its mandated CWANA eco-region. This region stretches through Mauritania to the west, Pakistan to the east, Kazakhstan to the north and Ethiopia to the south. It includes some of the world's poorest countries and features among those regions with the highest population growth rate in the world. However, ICARDA has both global and regional mandates: for example, it has a global responsibility to improve barley, lentil and faba bean crops, while its regional responsibilities within the CWANA region focus on the improvement of wheat, chickpea, forage and pasture crops, with additional emphasis placed on nutrition, rangeland improvement and small ruminant management. Other responsibilities include natural-resource management in dry areas, particularly with regard to water efficiency and use on farms.

While solutions to these problems require technological improvements, they also require new approaches to reverse land degradation that are firmly anchored in the socio-economic and policy contexts of the different countries and regions concerned. For example, ICARDA has been using a community-based approach in its Mashreq and Maghreb project, which not only focuses on strategies of target production (the traditional approach), but also on strategies considering local communities and their livelihoods. This approach aims to:

- foster integration among the stakeholders;
- stimulate stakeholder participation;
- facilitate technology transfer;
- promote collective action; and
- improve livelihoods and human welfare.

Multi-disciplinary teams of stakeholders work alongside the communities targeted. The strategy involves agro-ecological characterization and the development and transfer of appropriate technologies; first to the community and then, via modeling and scenario-building, to other communities and stakeholders, thus beginning the process of benefit scaling.

Through this approach, local institutions and communities develop and select appropriate technologies as part of a negotiated action plan. The project develops not only technological options but also policy and institutional options as part of a holistic approach to natural-resource management.

Through the negotiated action plans, options are selected with local stakeholders, who test, modify and monitor them. From this process, communities can develop their own action plans. The technologies introduced and developed within this specific Maghreb and Mashreq project include improved barley production, on-farm feed production, feed blocks, cactus and fodder shrubs, improved small ruminant production and pasture rehabilitation.

The WANA region harbours genetic resources for some of the most widely cultivated crops in the world, yet this precious resource is under serious threat from desertification. *Mousterde's Flora*, published in 1953, recorded nine hundred plant species in the Jabal El-Arab area of Syria, which is considered a haven for biodiversity. However, an inventory study carried out in the same area in 1996–2000 revealed only 512 of these original species. The loss of over 50 percent of these plant species over the last fifty years is extremely alarming, and calls for immediate action. ICARDA has been very active in collecting and preserving genetic biodiversity from targeted areas.

Currently the centre holds in its gene bank over 127,000 references of its mandated crops and their wild relatives. Some of these are now irreplaceable. ICARDA is also involved in *in situ* conservation, which permits adaptation of material to changing environmental conditions.

The community approach is also used to promote *in situ* conservation of precious genetic resources that are threatened by human encroachment. ICARDA, in co-operation with the Arab Center for the Study of Arid Zones and Drylands (ACSAD) and the International Plant Genetic Resources Institute (IPGRI) is coordinating a major project on *in situ* dryland-plant genetic diversity conservation in the region, involving Syria, Lebanon, Jordan and Palestine. Funded by the United Nations Development Programme's Global Environment Facility (GEF-UNDP), the project is aimed at conserving biodiversity in its natural habitat through environmentally friendly management of natural resources. For example, communities in the project area are building low-cost water-harvesting structures to improve water conservation and to protect local biodiversity. Improving management of water resources also enables these communities to plant more trees, further reducing land degradation.

Our partnerships are also geared to link research to development. A good example is the project in Marsa Matrouh, a semi-desert area on the Mediterranean coast of Egypt with an average annual rainfall of 150 millimetres. This collaborative project uses a strong adaptive research

and technology transfer base to break the degradation cycle and improve the livelihoods of the local nomadic populations. Water harvesting and conservation, and their effective utilization for high-value fruit trees and other crops, are the major agricultural activities of the project at this site. The communities, with project assistance, have constructed water cisterns and reservoirs to store rainwater and have built stone dykes that hinder or reduce water flow from the plantation areas to the Mediterranean Sea.

Another example comes from the Khanasser Valley in Syria, where scientists and farmers have conducted experiments together in olive groves in which different tillage regimes have been applied and cover crops and terraces have been used to prevent soil erosion. This will eventually lead to increased olive production, which in turn will contribute to improving the livelihoods of rural communities. Examples of the technologies employed and developed by ICARDA and its partners include the use of spineless cacti as a feed source for animals in the desert margin. Cacti are well adapted to harsh conditions and cover an area of approximately two hundred thousand hectares in North Africa alone. Jordan is currently undertaking a project to promote the use of cacti, and communities in Syria have already begun cacti plantation.

ICARDA's Mashreq and Maghreb project has been successful in developing alternative feed sources. Feedblocks are much cheaper than other sources of feed. In Iraq, fourteen hundred sheep owners use over three thousand tonnes of feedblocks made from agricultural by-products annually. This technology is being widely adopted by farmers, particularly in Jordan, Iraq and Syria. It is providing new opportunities for employment and income generation while forging new partnerships with the local private sector.

Another example of this multidisciplinary approach to natural-resource management is taking place in *wadis* near Marsa Matrouh on Egypt's north coast. ICARDA has worked to devise environmentally friendly ways of making the *wadis* more productive and is looking into the conservation and development of the steppe area. For our work in the *wadi* we use Geographic Information Systems (GIS), whereby soil and water data are overlaid onto a topography map, to ascertain the source and direction of water flow. ICARDA has developed a fully functional GIS laboratory at its headquarters. Research conducted by ICARDA on developing suitable micro-catchments to support vegetative cover in the fragile environments in Syria, Jordan, Egypt and Morocco has shown considerable success. The mechanized ridges developed and implemented in collaboration with the Syrian national program in Mehasseh increased the shrub survival rate from 10 to 90 percent. Three consecutive drought years were unable to dry out the plantations, which in this way contribute to reducing land degradation in these areas.

Fencing can provide one simple solution to protect biodiversity and halt desertification, but only under certain conditions and if the seed-bank contained in the soil has not been removed by the wind or died out. However, areas must not be fenced for too long. Grazing, if properly managed, is an integral part of rangeland management. In severely degraded rangelands, *range pitting* has been successfully applied by ICARDA. Our work has also demonstrated that the degradation of commonly owned marginal land can be reversed by applying phosphate fertilizer, re-seeding with native vegetation, and deferring the grazing of flowering pasture legumes. Phosphate fertilizer increases the population of leguminous species threefold, as well as providing increased live-weight and milk productivity in sheep and goats. Rangelands can also play a very important role in controlling global warming, through carbon dioxide assimilation. Monitoring carbon dioxide sequestration is an important component of ICARDA's research program. To this end, Bowen ratio equipment has been used by ICARDA in Uzbekistan and Kazakhstan to measure the amount of carbon absorbed by rangelands.

Technological interventions are seldom enough to reverse land degradation. Attention also has to be paid to land-tenure issues, especially on the common lands and rangelands of the CWANA region, and to the increasing role of women in managing natural resources. Research on policy and property rights is an integral component of ICARDA's research program. A study in Yemen, for example, is looking into why terrace farming in Yemen has lost its importance and why terraces are falling into disrepair, and how these trends can be reversed. Community participation in designing rehabilitation techniques is a key component of the International Development Research Centre (IDRC) supported research project on natural-resource management in Yemen.

The vast size of the region suggests that changes in land-use patterns will have global implications. A focus of potential carbon sequestration can help illustrate this point. In the WANA region alone, estimates of the likely losses of soil carbon as a result of agriculture range from six to twelve pita grams of carbon. It is assumed that 60 percent of this loss can be recovered using technologies that ICARDA has helped to develop, such as long-term crop rotations with cereals/legumes; more efficient use of nitrogen and phosphorus fertilizers; improvements in water-use efficiency; conservation-minded tillage methods; improved crop-livestock integration; and better resource use with efficient germplasm.

The potential for carbon sequestration using these technologies has been estimated to be 0.2–0.4 pita grams of carbon per year during the restoration phase. This translates into a monetary value of US\$840 million to US\$1 billion per year at a price of US\$5 per tonne of carbon. It is important to note that this amount is of the

same order as the projected costs of importing grain into the WANA region in the year 2020 and is therefore highly relevant for the economies of the WANA countries.

The re-accumulation of carbon in the soil is desirable not only for alleviating climate change but also in terms of land degradation; as increased soil organic matter generally improves soil's fertility, water-holding capacity and resistance to erosion. Realizing this potential requires the creation of enabling environments. Issues of private and communal ownership of land and policy incentives at regional, national and international levels (e.g. the implementation of the Kyoto protocol) are important considerations.

ICARDA has increased its engagement with National Agricultural Research Systems (NARS) and other regional and international organizations, to prepare action plans for the implementation of the UN Convention to Combat Desertification (UNCCD) to control land degradation and mitigate the effects of drought. ICARDA is a focal point for the CGIAR in the Global Mechanism and the UNCCD. This year we anticipate the activation of UNCCD action plans and the completion of an inventory study and pilot-size projects in six West Asian countries by ICARDA for the Thematic Network 1 (TN1) of the sub-regional program for West Asia.

To express their support of global conventions through the UNCCD and to consider the challenges critical to the development of drylands in the region, thirteen WANA countries, represented by seventeen Ministers of Agriculture, Environment and Finance, met with representatives from donor agencies and regional and international organizations in Rabat in June 2001. The meeting resulted in the "Rabat Declaration", which identified key areas for joint action. The Rabat Declaration reflects these countries' strong support for its implementation, entrusting ICARDA to take follow-up action. A follow-up meeting to the Rabat Declaration took place at ICARDA in March 2002. High-ranking representatives from WANA countries and from the International Fund for Agricultural Development (IFAD), the Global Mechanism and the World Bank participated. The meeting reviewed a draft of a regional work plan for which the participating donor representatives assured their support. ICARDA was assigned the role of coordinator for the project.

Reversal of trends in land degradation in CWANA requires a holistic approach focusing on three key components. Firstly, technological interventions must address land-, water- and food- security problems. Secondly, the active involvement of local communities within a strategy that increases their knowledge and organizational capacity is called for. With increased capacity to manage risk and to solve problems, communities can reverse land degradation, improve their livelihoods and become responsible stewards of natural resources. Thirdly, appropriate incentives at the policy and institutional level are

required to induce land users to adopt more conservation technologies.

ICARDA is only one player in this process, and it welcomes the opportunity to engage in dialogue and cooperation with organizations such as UNESCO and the United Nations University (UNU). We look forward to continued collaboration in the future.

## 2 UNESCO'S Man and the Biosphere Programme and the World Network of Biosphere Reserves – Conservation and Rehabilitation Using Biosphere Reserves

*Thomas Schaaf, Programme Specialist, Division of Ecological Sciences, UNESCO-MAB, Paris, France*

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UNESCO, the United Nations Educational, Scientific and Cultural Organization, launched one of the first international study and research programmes on arid and semi-arid zones in 1951. This programme became a Major Project in UNESCO during the period 1957–1964. The hallmark of its success was to employ a holistic and interdisciplinary approach involving both the natural and the social sciences, which was recognized as improving knowledge of the dynamics of dryland ecosystems. In 1968, UNESCO organized an International Biosphere Conference in Paris, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), the International Council of Scientific Unions (ICSU), the World Conservation Union (IUCN — formerly the International Union for the Conservation of Nature and Natural Resources) and other partners. This proved to be a landmark event. This conference recommended the launching of a worldwide research programme on the interactions between humankind and the biosphere.

The UNESCO General Conference endorsed this recommendation at its session in 1971, and officially launched the Man and the Biosphere (MAB) Programme. UNESCO's earlier Major Project on Arid and Semi-Arid Zones became part of the MAB Programme, and was the focus of one of several ecosystem-oriented research themes (others included tropical forests, coastal areas, and mountain ecosystems). From the positive experience of the Major Project on Arid and Semi-Arid Zones' holistic and interdisciplinary research, this approach was adopted by the Man and the Biosphere Programme and has since shaped its distinctive features.

The MAB Programme is an international environmental research and conservation programme incorporating the natural and social sciences. It aims to develop the basis for the sustainable use and conservation of natural resources, while improving the relationship between people and their environment, thus encouraging interdisciplinary research, demonstration activities and training in natural-resource management. MAB contributes not only to a better understanding of the environment, including

global change, but also to a greater involvement of science and scientists in policy development regarding the rational use of natural resources. The establishment of biosphere reserves as sites for environmental conservation, research, and the participation of local people in decision-making processes, demonstrates in particular MAB's integrated approach towards better management of the environment.

The MAB Programme came into existence some thirty years ago and was initially designed around a total of fourteen MAB Project Areas, or themes. These are listed in the box overleaf. It is worth noting that the MAB Programme adopted an ecosystem approach whereby the impact of human activities on a given ecosystem was central to the work undertaken. MAB Project Area 4, entitled Impact of Human Activities on the Dynamics of Arid and Semi-Arid Ecosystems, was the logical continuation of UNESCO's work on drylands.

Within the framework of MAB Project Area 4, several UNESCO-MAB Pilot Projects were implemented in Africa. These included:

- The integrated Project on Arid Lands in Kenya (IPAL-Kenya), with follow-up projects by the Kenya Arid Lands Research Station (KALRES) and the Turkana Resources and Evaluation Monitoring Unit (TREMU);
- The integrated Project on Arid Lands in Lesotho (IPAL-Lesotho);
- The integrated Project on Arid Lands in Southern Tunisia (IPAL-Tunisia);
- The training and Education on Integrated Pastoral Management in the Sahel (FAPIS, *Formation en Aménagement Pastoral Intégré au Sahel*) project;
- The strengthening of Scientific Capacities in the Agro-Silvo-Pastoral Domain (CILSS member states, West Africa);
- The cooperative Integrated Project on Savannah Ecosystems in Ghana (CIPSEG).

Common to all projects was a focus on capacity-building among the national and international scientists

## The Fourteen MAB Project Areas/Themes from 1971–1991:

1. Ecological Effects of Increasing Human Activities on Tropical and Subtropical Forest Ecosystems.
2. Ecological Effects of Different Land Uses and Management Practices on Temperate and Mediterranean Forest Landscapes.
3. Impact of Human Activities and Land-Use Practices on Grazing Lands: Savannah and Grassland (from Temperate to Arid Areas).
4. Impact of Human Activities on the Dynamics of Arid and Semi-Arid Ecosystems.
5. Ecological Effects of Human Activities on the Value and Resources of Marshes, Rivers, Deltas, Estuaries, and Coastal Zones.
6. Impact of Human Activities on Mountain and Tundra Ecosystems.
7. Ecology and Rational Use of Island Ecosystems.
8. Conservation of Natural Areas and of the Genetic Material they Contain.
9. Ecological Assessment of Pest Management and Fertiliser Use of Terrestrial and Aquatic Ecosystems.
10. Effects of Man and his Environment Caused by Major Engineering Works.
11. Ecological Aspects of Urban Systems with Particular Emphasis on Energy Utilization.
12. Interactions between Environmental Transformations and the Adaptive, Demographic and Genetic Structure of Human Populations.
13. Perception of Environmental Quality.
14. Research on Environmental Pollution and its Effect on the Biosphere.

through the interdisciplinary nature of the environmental studies. To illustrate the integrated approach of these projects, two examples of MAB pilot projects in arid lands are outlined below.

The Cooperative Integrated Project on Savannah Ecosystems in Ghana (CIPSEG) attempted to define environmental conservation based on socio-cultural parameters. The project, which was carried out during 1993–1997 in northern Ghana's savannah region, adopted an integrated and inter-disciplinary approach to traditional belief systems and sacred groves to study sustainable development and dryland conservation.

In Ghana, as in most other African countries, rapid population growth and the expansion of economic activities has led to deforestation and degradation of the environment. In many parts of the country, bush fires, agricultural cultivation, overgrazing, firewood collection, urbanization and village sprawl have seriously damaged the natural vegetation. Although northern Ghana with its dry sub-humid savannah of the Guinea type suffers widespread environmental degradation, small pockets of residual closed-canopy forests still remain and are located in proximity to human settlements. Many of these forest pockets are, in fact, sacred groves, which have survived environmental degradation because of religious belief systems. Almost all existing sacred sites in Ghana have been, and continue to be, protected by taboo, traditional beliefs and local custom. The population's reverence for and general perception towards sacred groves has prevented encroachment and unwarranted exploitation of resources within these sacred sites.

With this situation in mind, UNESCO-MAB's CIPSEG project aimed to assess whether sacred groves could be assigned

as indicator sites for the natural vegetation of the savannah area. The project begged the question as to whether these groves were representative of the savannah originally present here before human pressure grew too strong. The project's goal was to study and develop a scientific knowledge base on the relic sacred groves' ecosystems, in terms of their plant- and animal-species compositions. This knowledge base was then used in efforts to achieve the project's second main objective — to restore the adjacent and degraded savannah areas by using the gene pool of the native plant species found in the sacred groves. The project's aim was therefore twofold: to study the sacred groves' genetic resources (a scientific orientation) and to rehabilitate the degraded environment (a development orientation).

To address these two main objectives, several scientific teams were set up within an interdisciplinary framework. The University of Ghana's botany department carried out plant inventories in the three selected sacred groves. The same university's geography department looked into the land-use systems in place in the three districts in which the sacred groves are found, with a view to elaborating environmentally-sound management plans. Apart from conducting ecological research, the project attached great importance to the socio-cultural dimensions of the sacred groves. The Centre for National Culture in Tamale undertook in-depth studies of the traditional beliefs that had led to the protection of the sacred sites; the same centre also analysed the function of sacred groves in ceremonial purposes performed by priests. Other studies focused on traditional resource-use of village communities; such as tree planting and ownership of tree and forestry

products. These studies were particularly important for the restoration of degraded savannah environments in order to meet the specific needs of village communities without violating cultural values.

Environmental education on the importance of conservation, aimed at involving local people, was considered essential for the success of the project. The project's main counterpart institution, the Environmental Protection Agency of Ghana, carried out multi-layered education programmes such as organizing thematic seminars on controlling and preventing bushfires (which could seriously affect the sacred groves), on establishing shelterbelts around the groves, and on training women in tree planting techniques.

Research on the cultural aspects and significance of the sacred sites drew fascinating conclusions. Through interviews conducted with the village elders, and the subsequent extrapolation of historic events, it was established that some of the sacred groves are over three hundred years old. They were originally considered to be home to a god or several gods. The three selected groves were the respective abodes of a python god, a leopard god, and a monkey god, who commanded bountiful or lean harvests. Other sacred groves in the study area served and still serve as burial grounds of ancestors and have become taboo over time. The chief's power is intrinsically linked to his function as supreme custodian of the sacred grove. Regardless of whether the chief is a practicing Muslim or Christian, his power over the community derives from his role as the protector of the sacred grove. Should he relinquish this function, his power as the chief would be forfeited. The taboos and obligations vary with each sacred site, but there are several common features. For instance, creating shelterbelts around the groves is a duty in village communities. The strict observance or adherence of the rules associated with the sacred groves is considered important and cannot be compromised.

However, as culture is dynamic, even belief systems change over time — many young people wish to extend their agricultural lands, even if this involves encroaching into the sacred grove. The project therefore re-oriented its activities by employing agro-forestry methods with regard to the rehabilitation of degraded lands around the sacred groves. These permitted cash-crop production (e.g. cashews, mangoes etc.), and provided an economic income to local people, especially women and young men. At the same time, the restoration of vegetation cover in particularly degraded areas was ensured. The establishment of wood lots and fodder banks were additional means to create "buffer zones" around the sacred groves. These buffer zones provided income benefits for local people (agro-forestry, wood lots, fodder banks, cash crops etc.) and the pressure on the sacred site was thus considerably reduced.

## 1. The World Network of Biosphere Reserves

The CIPSEG Project in Ghana also illustrates how the MAB programme is increasingly addressing the central question posed at the *United Nations Conference on Environment and Sustainable Development* (UNCED, Rio de Janeiro 1992): How are we to reconcile environmental conservation (i.e. in the drylands) with ensuring sustainable development and the sustainable use of biological resources? One solution could be the approach adopted by UNESCO in its World Network of Biosphere Reserves, which combine environmental conservation with economic activities based on spatial analyses and scientific land-use and land-management studies.

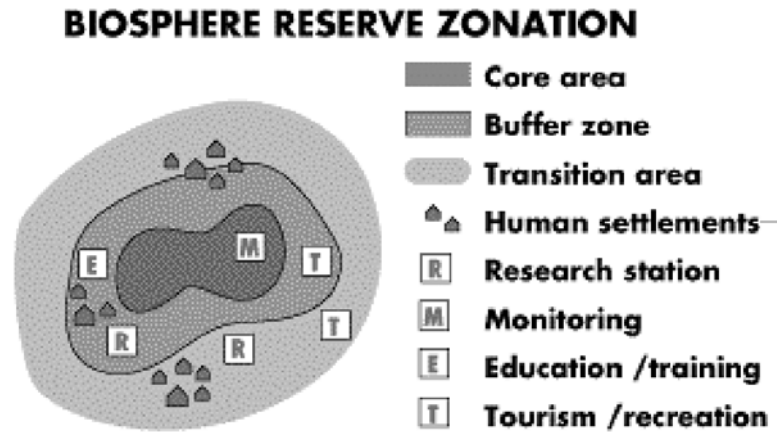
Biosphere reserves are defined as areas of terrestrial and coastal ecosystems that are internationally recognized within the framework of UNESCO's Man and the Biosphere Programme (MAB), collectively constituting a World Network. They are nominated by national governments and must meet and adhere to a set of criteria and conditions before being admitted into the World Network. Each biosphere reserve is expected to fulfill three basic functions, which are complementary and mutually reinforcing:

- a *conservation function* — to contribute to the conservation of landscapes, ecosystems, species, and genetic variation;
- a *development function* — to foster socio-culturally and ecologically sustainable economic and human development;
- a *logistic function* — to provide support for research, monitoring, education, and information exchange related to local, national and global issues of conservation and development.

To carry out the complementary activities of nature conservation and the utilization of natural resources, biosphere reserves are organized into three interrelated zones, known as the core area, the buffer zone, and the transition area (see Figure 1).

- The **core area** needs to be legally established and give long-term protection to the landscape, ecosystem and species it contains. It should be sufficiently large to meet these conservation objectives. As nature is rarely uniform and as historical land-use constraints exist in many parts of the world, there may be several core areas in a single biosphere reserve, ensuring a representative coverage of the mosaic of ecological systems. Normally, the core area is not subjected to human activity, apart from research and monitoring activities, though in some cases they may be subjected to traditional extractive uses by local communities.

Figure 1: Schematic Zonation of a Biosphere Reserve



- A **buffer zone** is clearly delineated and surrounds or is contiguous to the core area. Activities are organized here in such a manner that they do not hinder the conservation objectives of the core area but rather help to protect it, hence the idea of “buffering”. Buffer zones can be areas for experimental research — i.e. to discover ways to manage natural vegetation, croplands, forests, and fisheries so as to enhance high-quality production while conserving natural processes and biodiversity, including soil resources. In a similar manner, experiments can be carried out in the buffer zone to explore how to rehabilitate degraded areas.
- An outer **transition area**, or area of cooperation may incorporate a variety of agricultural activities, human settlements and other uses. It is here that local communities, conservation agencies, scientists, civil associations, cultural groups, private enterprises and other stakeholders must agree to combine efforts to manage and develop in a sustainable manner the

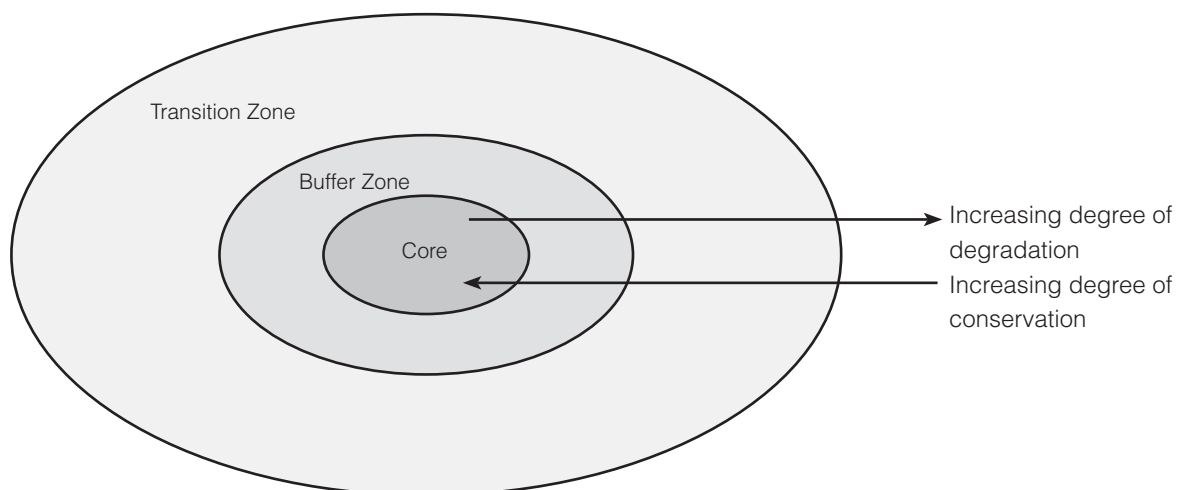
area’s resources for the benefit of the people who live there. Given the role that biosphere reserves play in promoting the sustainable management of the natural resources of the region, the transition area is of great economic and social significance for regional development.

Although presented schematically as a series of concentric rings, the three zones are often allocated in many different ways to accommodate local geographic conditions and constraints. This flexibility allows for creativity and adaptability, and is one of the concept’s greatest strengths.

The World Network is formally recognized by the 188 Member States of UNESCO. To date (May 2002), there are 409 biosphere reserves in 94 countries (for the locations of each individual biosphere reserve, years of inscription, site descriptions and contact persons in charge of the reserve, refer to <http://unesco.org/mab/wnbr.htm>).

While there is a strong concentration of biosphere reserves representing humid tropical forest zones, moun-

Figure 2: Transects through a biosphere reserve



tain ecosystems, and temperate zones, fewer biosphere reserves exist in the world's drylands. However, some biosphere reserves have been nominated in arid and semi-arid areas: the Bogeda and Xilin Gol Biosphere Reserves in the People's Republic of China, the Great Gobi Biosphere Reserve in Mongolia and the Wadi Dana Biosphere Reserve in Jordan.

According to a decision by the MAB International Coordinating Council at its session in March 2002, the rehabilitation of degraded drylands using biosphere reserves should be a new focus in the MAB research programme. Essentially, the programme would compare the relatively undisturbed core areas of the biosphere reserves with the economic function of the transition areas for rehabilitation purposes. A transect across the different zones of the biosphere reserve would reveal the varying degrees of environmental conservation or, inversely, environmental degradation, that can be observed (See figure 2).

With this in mind, the present workshop should address the following questions:

- Can core areas of biosphere reserves be considered as "reference sites" for assessing potential natural vegetation and for ensuring viable wildlife populations in drylands?
- Can restoration activities be carried out in the buffer and transition zones of biosphere reserves using the gene pool contained in the core areas?
- Which cash crops or multi-purpose species have proven particularly successful for dryland rehabilitation and for generating income for local people in the drylands, especially in buffer and transition zones?
- Can traditional knowledge help to combat desertification? Is there a complementary way of combining traditional and modern rehabilitation techniques? E.g. the use of organic farming techniques in the Dana Biosphere Reserve, Jordan.
- Can suitable test sites (biosphere reserves) be identified for joint research on dryland rehabilitation in several countries?

We hope that this workshop can provide some answers to these questions. UNESCO-MAB, the United Nations University (UNU) and the International Center for Agricultural Research in the Dry Areas (ICARDA) are also joining forces to implement a project entitled "Sustainable Management of Marginal Drylands".

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# 3

## Approaches Towards the Integration of Land-Management Practices: UNU's Experience in Networking and Capacity Development

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### Abstract

The United Nations University (UNU) strives to assist developing countries in dry areas to manage their land resources and to achieve sustainable utilization of biodiversity and water resources. Integrated management of natural resources and the development of multi-disciplinary approaches is the key to achieving these objectives. In accordance with its mandate, the UNU has focused on the development of a network of researchers, interacting between researchers and academia on the one side and the UN system on the other. Development of the capacity to undertake research into the conservation of natural resources in drylands is central to the UNU's activities. Another key element is the development of broad partnerships with international, national, and regional institutions, particularly those within the UN system.

### 1. Background

The most vulnerable areas in any ecosystem are those situated at its periphery. Most land erosion, degradation in soil quality, biodiversity loss, and the loss of productivity that ensues occurs in these marginal but high priority lands. This is particularly true for "dry areas"; those comprising arid, semi-arid and dry sub-humid regions. Sustainable management strategies in these dry areas are needed for the protection, preservation and reclamation or rehabilitation of these fragile systems and the natural resources contained within them. Such strategies are closely linked to human development and the quality of life in these marginal areas.

#### 1.1 LAND DEGRADATION AS A GLOBAL PROBLEM

Land degradation is defined as a process that leads to the reduction of land productivity for useful purposes, and is typically a result of soil, wind, or water erosion; soil salinization; waterlogging; chemical deterioration; or any combination of these factors. Land degradation is a global problem whereby marginal lands are turned into wastelands and natural ecosystems are destroyed. The

immediate causes include deforestation, poor management of water resources; inappropriate land-use practices; overuse of chemicals, fertilizers and pesticides; and domestic and industrial waste disposal. The underlying driving forces include rapidly increasing populations, economic policies that over-exploit natural resources, and rapid and often poorly managed industrial and urban development. The impacts of land degradation are severe on both human society and ecosystems.

The UN estimates that 70 percent of the 5.2 billion hectares of drylands used for agriculture around the world is already degraded (UNEP, 2000). This affects approximately 250 million people across the world — some estimates put the number of people at risk as being four times greater. As an example, arable land per person worldwide was reduced by as much as 25 percent in the last quarter of the twentieth century. This has serious implications for food security and the livelihood of people dependent on these progressively degraded lands. The impact of land degradation on ecosystems is apparent in the destruction of biodiversity resources. According to UNEP estimates, about 65 million hectares of forest were lost globally in the five years from 1990 to 1995. The resultant loss in biodiversity at the genetic, the species and the community level was also severe. These projections demand the attention of the international community and a coordinated effort to overcome these challenges.

#### 1.2 INTEGRATED LAND-MANAGEMENT APPROACHES

Developing integrated approaches is critical to minimizing land degradation and related societal and economical impacts. There is a need to promote actions to build and strengthen existing institutional capacities so that national-, regional- and basin-level agencies can effectively address and integrate cross-sectoral aspects. But defining such integrated approaches is a complex task, and the outcome varies depending on the region. To develop a general framework for such integrated approaches, the following four dimensions of the problem must be considered.

a) Technical Dimensions:

- All renewable natural resources (water, soil, vegetation, etc.) should be taken into account when developing integrated management programs;
- innovative solutions for managing land degradation must be identified, mainly through water-use efficiency and productivity and soil conservation;
- potential conflicts and synergies between highlands and lowlands should be given due consideration, particularly because highlands and mountains serve as water towers for the lowlands;
- due consideration should be given to trans-ecozone characteristics of resources, especially water. Planning and conflict resolution on a trans-ecozone level has become crucial to approaches to improve the resources situation in dry areas.

b) Human Dimensions:

- Localized approaches to land ownership and land tenure are often critical in the conservation of resources;
- impacts on the livelihood of local people need to be considered when designing and discussing resource-management approaches — alternative livelihoods for affected communities have to be developed;
- effects of indigenous practices on natural resources, positive and negative, should be accounted for;
- mechanisms for conflict resolution during the implementation of management approaches should be built into the programmes.

c) Economic Dimensions:

- Social, environmental, and economic costs and benefits have to be evaluated to ensure the long-term sustainability or viability of integrated approaches;
- capital investment is needed to develop new infrastructures and to maintain existing and traditional practices;
- links to national economic development should be elaborated.

d) Natural-Resource Dimensions:

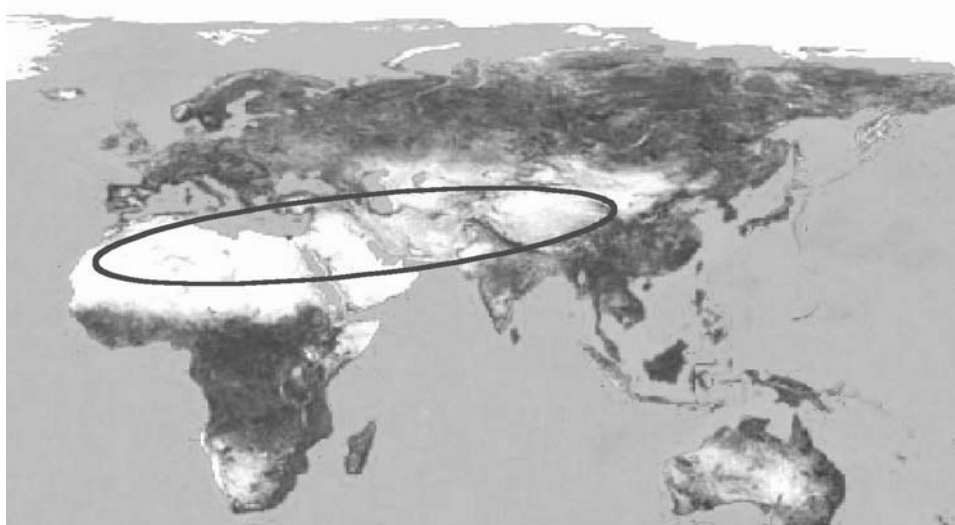
- Rehabilitation of ecosystems in marginal lands should have the highest priority in integrated programmes;
- *in situ* conservation of biodiversity within ecosystems, whenever applicable, should be considered.

These four dimensions are closely interlinked, and need to be considered explicitly to develop fully integrated approaches. A number of international organizations are already working towards the development of such approaches, although successful examples of such programmes are few.

### 1.3 TARGET OF UNU'S ACTIVITIES

UNU's activities are geographically focused on developing countries in dry areas, particularly the region comprising Northern Africa, Central Asia, the Middle East and China. This region is shown graphically in Figure 1.

*Figure 1: The Regional Focus of UNU's Activities.*



UNU's activities are developed with the following objectives in mind:

- to facilitate development of integrated management approaches for the sustainable utilization of natural resources in marginal lands, including land, water and biodiversity resources;
- to identify key research areas in land and natural-resource management that benefit most from capacity building;
- to develop appropriate capacity-building programmes, with an emphasis on South-South collaboration to transfer environmentally-sound technologies;
- to catalyze development of networks of researchers and institutions working in various disciplines and geographical settings.

## 2. UNU's Network Development and Research Activities

UNU has identified four thematic areas of priority for its activity on drylands:

- a. Sustainable management of marginal drylands
- b. Innovative water-management in dry areas
- c. Capacity development for integrated land-management in dry areas
- d. Traditional water-management in dry areas

All four thematic areas are linked through a series of international workshops that are held once a year in different locations within UNU's network. The themes of these workshops are selected in accordance with thematic areas with special consideration of the key sustainability issues encountered in the region where they are held. These workshops have resulted in the publication of the UNU Desertification Series, which includes the following publications: UNU (1998), UNU (1999), Adeel (2001a) and Adeel (2001b).

Two key activities under these thematic areas are described in further detail in this section.

### 2.1 SUSTAINABLE MANAGEMENT OF MARGINAL DRYLANDS

This project is a joint collaboration between UNU, UNESCO and ICARDA. It employs a systematic approach to the long-term *in situ* conservation of natural resources, by involving and supporting local populations in their efforts to use their natural resources in a sustainable way and by putting science to work to improve the management of marginal areas. It relies on existing projects and activities within institutional networks such as UNESCO's World Network of Biosphere Reserves, research institutions associated with the United Nations University, and ICARDA field stations, thus discouraging an *ad hoc* approach. It aims *inter alia* at

creating a coordinated network of study sites linked by a common understanding of purpose, which will create synergy by providing benefits to each participating site.

The combination of ICARDA's expertise in dryland agriculture, UNU's expertise in dryland ecosystem research, and UNESCO's applied field studies on desertification and environmental conservation ensures an inter-disciplinary approach. Participating partners represent a variety of scientific disciplines: they include ecologists; agricultural, pastoral and forestry scientists; soil and water scientists; economists; sociologists; and managers of protected areas.

The following activities are to be carried out to achieve the project's objectives:

- Comprehensive assessment methodologies of integrated natural-resource management will be developed.
- For each study site, an assessment will be made of the current status of the integration of natural-resources conservation, community development, scientific research, and management and cooperation mechanisms. This assessment will include socio-economic surveys to identify and understand people's adaptation to management approaches.
- Practices for sustainable soil and water conservation will be promoted using a site-specific approach. These will include the application of traditional knowledge and modern expertise.
- Associated training in data-collection and inventory techniques and in proven management technologies will be carried out based on the specific needs identified at each site.
- At each site, one or two income-generating activities based on the sustainable use of dryland natural resources will be explored and supported, within the financial constraints/limits of the project.
- National workshops and group training programmes will be organized on dryland-conservation issues, land management, rehabilitation of degraded areas, and the sustainable and rational use of natural resources.
- Annual international meetings are to be held.
- The results of the project will be published and widely distributed by UNU, UNESCO and ICARDA, to achieve multiplier effects.

### 2.2 TRADITIONAL WATER-MANAGEMENT TECHNOLOGIES IN DRY AREAS

There are a number of examples of traditional water-management systems that have fallen by the wayside due to pressure from more recent technologies or due to incorrect propositions provided by experts from the North. There is a strong need to fully understand these traditional water-management processes and the way in which they interact with societies located in dry areas.

This project focuses on solutions that take into account the socio-economic conditions in these countries and that are acceptable to local communities. It evaluates the relationship between local communities and traditional water-management systems, including evolution of these systems in contemporary societies. In the process, it also develops the capacity of local researchers to undertake community-oriented field research and to raise public awareness of key issues pertaining to the utilization of traditional water-management technologies.

The project provides limited funds to carry out community-based field research activities. The key selection criteria for activities under this project include:

- on-going activities in an active research area,
- *in situ* field work,
- due consideration to community involvement.

### 2.3 CAPACITY DEVELOPMENT IN THE REGION

Developing countries in dry areas can better prepare to cope with challenges resulting from land degradation if they have appropriate human resources. Training professionals in a multidisciplinary environment — where they can learn to deal with the broad range of issues related to integrated management of land resources — is thus important. In this context, the UNU is undertaking the development of a Master of Science degree in Integrated Land Management. This programme will be undertaken in collaboration with the *Institut des Régions Arides* (IRA) in Médenine, Tunisia, and the Institute of Desert Research at the Chinese Academy of Sciences in Lanzhou, China. Such a degree programme can make an important contribution to the process of building professional capacity to tackle land-degradation problems.

The academic programme will adopt a multi-disciplinary approach to the coursework required, and will include field research work as an integral component. The thematic content of the programme may be tailored to suit individual career development but must be geared towards practical applications. Candidates will be required to demonstrate that their proposed research area involves *in situ* field work and gives due consideration to community involvement.

### 2.4 SUMMARY OF KEY FINDINGS FROM THE PROJECT

Since its implementation in 1998, a number of findings and recommendations have emerged from the UNU's initiative on dry areas. Soome are specific to problems in the region under focus or within the thematic area of discussion. However, a more generalized set of findings has also emerged. These are summarized below:

- Levels of stress in dry areas are increasing, due to a number of human-induced factors. These factors include high population growth rates, climate

change and variability, a reduction in available water resources, and a general over-exploitation of natural resources. This additional stress translates to a higher level of threat.

- Approaches to combat the problems of land degradation can only succeed by integrating and incorporating all the dimensions of land management (as summarized above). In this context, community involvement is absolutely vital. Women often play a central role in the management of natural resources within these communities.
- Networking is a very effective method of disseminating information among researchers, policy makers, and the general public. From UNU's experience, it is also evident that networks play a crucial role in enhancing collaborative research work and assist in the cross-fertilization of ideas across national and regional borders.
- Developing countries often do not have the capacity to adopt integrated management approaches effectively. Thus, capacity building has to become a central element towards such an approach.

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## Session I: Principles of Dryland Restoration/Rehabilitation in Biosphere Reserves in Africa

# 4

### Monitoring the Flora of the Omayed Biosphere Reserve and Measures for Rehabilitation

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#### Abstract

The Omayed Biosphere Reserve has a peculiar landscape of alternating ridges and depressions that extends along a twenty-kilometre north-south transect and ends with a vast inland plateau. This heterogeneity makes it possible to differentiate seven major habitats (coastal sand dunes, saline depressions, non-saline depressions, inland ridges, inland plateau, inland siliceous deposits, and rain-fed farms), each with its characteristic flora and vegetation. Recent monitoring (autumn 1998 to summer 2000) recorded 251 plant species (131 perennials and 120 annuals) belonging to 169 genera and 44 families. Among these species, one is endemic, 40 are rare (23 perennials and 17 annuals), 19 are noteworthy species and 11 species are under threat. Fifty-eight species are woody plants (mainly shrubs), contributing about 23.1 percent of the total species (10 phanerophytes and 48 chamaephytes). One hundred and twenty-nine species (51.4 percent of total species) possess at least one aspect that has a potential or actual economic use. Plants used for grazing purposes or for their medicinal properties are the most common. Forty-one plant communities were identified: eight in coastal sand dunes, four in non-saline depressions, three in rain-fed farms, four in salt marshes, eight in saline depressions, eleven in inland ridges, and three in inland siliceous deposits. From an ecological and vegetation viewpoint, we can conclude that the Omayed Biosphere Reserve is an ideal site representative of the Mediterranean Desert ecosystem in Egypt. Its flora makes up 30 percent of the species found in the Egyptian Mediterranean region (the richest phyto-geographical region in Egypt).

#### 1. Introduction

The Omayed Biosphere Reserve is located in the western Mediterranean coastal region of Egypt, eighty kilometres west of Alexandria. Its landscape is differentiated into a northern coastal plain and a southern plateau. The coastal plain is characterized by alternating ridges and

depressions running parallel to the coast in an east-west direction. This physiographic variation distinguishes seven types of habitats, as mentioned above. In the non-saline depressions, man-made rain-fed fig and watermelon plantations are common. Since 1974, the Omayed Biosphere Reserve has been subjected to intensive and extensive surveys and analyses covering most biotic and abiotic components of its ecosystems. This work has been carried out within the framework of two major projects: Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt (SAMDENE, 1974–1979); and Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt (REMDENE, 1979–1984).

Studies undertaken by Ayyad (1976), Abdel Razik (1976), Shaltout (1983 and (1985), Shaltout and Ayyad (1994), and Ayyad and Fakhry (1996) are examples of research dealing with vegetation analysis and species diversity in the Omayed Biosphere Reserve. El-Kady (1980), Ayyad and El-Kady (1982), and Shaltout and El-Ghareeb (1985) deal with the effect of protection and controlled grazing on the primary productivity of the ecosystem of non-saline depressions in this region. Some studies (e.g. Abdel Razik *et al.* 1988 a, b) evaluate the quality of the grazing flora species as fodder for domestic animals such as sheep and goats. Other studies deal with vegetation and land use, using remote sensing techniques (Salem 1989 and El-Kenany 1995) or aerial photography (Ayyad and Le Floch 1983, and Hammouda 1988).

This paper presents the results of a recent flora monitoring process conducted in the Omayed Biosphere Reserve over two years from autumn 1998 to summer 2000. It identifies the endemic, rare and threatened species as well as other noteworthy species (i.e. species with common or unique features or species with invasive or economic importance). Management and conservation measures and crucial directions for further research are also indicated.

## 2. Species Richness

A total of 251 species were recorded in the Omayed Biosphere Reserve, of which 131 were perennials and 120 annuals (i.e. therophytes). These species belong to 169 genera and 44 families. The composites contribute most to the total flora (15.9 percent), followed by grasses (13.2 percent) and legumes (12.8 percent). Thirty-two species (twenty-two perennials and ten annuals) have wide ecological amplitudes (recorded in at least six out of seven of the prevailing habitats). These species are:

A. Perennials: *Allium roseum*, *Echinops spinosissimus*, *Plantago albicans*, *Anabasis articulata*, *Echiochilon fruticosum*, *Salsola tetrandra*, *Artemisia herba-alba*, *Gymnocarpus decander*, *Salvia lanigra*, *Asphodelus ramosus*, *Helianthemum lippii*, *Scorzonera undulata*, *Atractylis carduus*, *Lotus creticus*, *Suaeda pruinosa*, *Carduncellus eriocephalus*, *Noaea mucronata*, *Thymelaea hirsuta*, *Cynodon dactylon*, *Lygeum spartum*, *Zygophyllum album* and *Deverra tortuosa*.

B. Annuals: *Adonis dentata*, *Hippocrepis areolata*, *Rumex pictus*, *Astragalus annularis*, *Ifloga spicata*, *Schismus barbatus*, *Filago desertorum*, *Malva parviflora*, *Senecio glaucus* subspecies *Coronopifolius* and *Matthiola longipetala* subspecies *Livida*.

The habitats with greatest species richness are the inland ridges (160 species) and non-saline depressions (156 species), while those with lowest species richness

are the rain-fed farms (65 species) and salt marshes (23 species). The habitat with the highest number of unique species was found to be the coastal dunes (35 species) (see Table 1 below).

Eighteen species have distribution restricted to the western Mediterranean region comprising the Omayed Biosphere Reserve. They are: *Asparagus aphyllus*, *Fagonia cretica*, *Lotus polyphyllus*, *Centaurea alexandrina*, *Helianthemum sphaerocalyx*, *Prasium majus*, *Centaurea pumilio*, *Hyoseris radiata* subspecies *graeca*, *Rhodalsine geniculata*, *Ebenus armetagie*, *Leontodon tuberosus* and *Thymus capitatus* as perennials; and *Brachypodium distachyum*, *Daucus syrticus*, *Hyoseris scabra*, *Crucianella aegyptiaca*, *Hippocrepis cyclocarpa*, and *Matthiola longipetala* subspecies *hirta* as annuals.

## 3. Endemic, Rare and Threatened Species

Only one rare endemic species, *Helianthemum sphaerocalyx*. (Cistaceae) is found in the coastal dunes of the region. Moreover, species of unique occurrence in the coastal sand-dunes region are considered as threatened species due to the severe destruction of the habitat as a result of the construction of tourist resorts. This process has led to the fragmented nature of this habitat. According to the schema of rare forms (Rabinowitz 1981), forty rare species were reported in Omayed Biosphere Reserve, of which twenty-three are perennials and seventeen are annuals (see Table 2 overleaf).

Table 1: Species richness of the main habitats in the Omayed Biosphere Reserve. The number of unique species (one of the criteria used in assessing nature reserves) found in each habitat is indicated.

| Habitat                | Perennial |        | Annual |        | Total |        |
|------------------------|-----------|--------|--------|--------|-------|--------|
|                        | All       | Unique | All    | Unique | All   | Unique |
| Coastal Dunes          | 74        | 19     | 53     | 16     | 127   | 35     |
| Salt Marshes           | 17        | 2      | 6      | 1      | 23    | 3      |
| Saline Depressions     | 52        | 2      | 43     | 1      | 95    | 4      |
| Non-Saline Depressions | 78        | 3      | 78     | 10     | 156   | 14     |
| Inland Ridges          | 79        | 4      | 81     | 9      | 160   | 16     |
| Inland Plateaux        | 59        | 7      | 46     | 2      | 105   | 6      |
| Rain-Fed Farms         | 35        | 4      | 30     | 3      | 65    | 4      |
| Total                  | 131       | 41     | 120    | 42     | 251   | 82     |

Table 2: Rare species identified in the Omayed Biosphere Reserve, based on Rabinovitz (1981)..

| Species                                               | Family          | Habitat    | Floral Category | Status     |
|-------------------------------------------------------|-----------------|------------|-----------------|------------|
| <b>A- Perennials</b>                                  |                 |            |                 |            |
| <i>Ammophila arenaria</i>                             | Gramineae       | CD         | ME              | Threatened |
| <i>Centaurea pumilio</i>                              | Compositae      | CD         | ME              | Threatened |
| <i>Elymus farctus</i>                                 | Gramineae       | CD         | ME              | Threatened |
| <i>Euphorbia paralias</i>                             | Euphorbiaceae   | CD         | ME+ES           | Threatened |
| <i>Hyoseris radiata</i> subspecies <i>graeca</i>      | Compositae      | CD         | SA              | Threatened |
| <i>Leontodon tuberosus</i>                            | Compositae      | CD         | SA              | Threatened |
| <i>Lotus polyphyllus</i>                              | Leguminosae     | CD         | ME              | Threatened |
| <i>Pancratium maritimum</i>                           | Amaryllidaceae  | CD         | ME              | Threatened |
| <i>Retama raetam</i>                                  | Leguminosae     | CD         | ME+SA+IT        | Threatened |
| <i>Silene succulenta</i>                              | Caryophyllaceae | CD         | ME              | Threatened |
| <i>Crucianella maritima</i>                           | Rubiaceae       | CD, IR     | ME              |            |
| <i>Ononis vaginalis</i>                               | Leguminosae     | CD, IR     | ME+IT           |            |
| <i>Salvia verbenaca</i>                               | Labiatae        | CD, ND, IR | ME+IT+ES        |            |
| <i>Frankenia revoluta</i>                             | Frankeniaceae   | CD, SD, ND | ME+IT+EU        |            |
| <i>Euphorbia hierosolymitana</i>                      | Euphorbiaceae   | SD         | ME+IT           |            |
| <i>Eminium spiculatum</i>                             | Araceae         | SD, ND     | ME+IT           |            |
| <i>Dactylis glomerata</i>                             | Gramineae       | ND, IR     | ME+IT+ES        |            |
| <i>Rhodalsine geniculata</i>                          | Caryophyllaceae | ND, IR     | SA              |            |
| <i>Stipa lagascae</i>                                 | Gramineae       | ND, IR, IP | ME+SA+IT        |            |
| <i>Asparagus aphyllus</i>                             | Liliaceae       | IR         | ME              |            |
| <i>Parietaria alsinifolia</i>                         | Urticaceae      | IR         | SA              |            |
| <i>Phlomis floccosa</i>                               | Labiatae        | IR         | ME              |            |
| <b>B- Annuals</b>                                     |                 |            |                 |            |
| <i>Reseda alba</i>                                    | Resedaceae      | CD         | ME+IT+ES        | Threatened |
| <i>Pseudorlaya pumila</i>                             | Umbelliferae    | CD, ND     | ME+SA           |            |
| <i>Sphenopus divaricatus</i>                          | Gramineae       | SM, IR     | ME+SA+IT        |            |
| <i>Atriplex leucoclada</i>                            | Chenopodiaceae  | SD         | SA+IT           |            |
| <i>Ammochloa palaestina</i>                           | Gramineae       | SD, ND, IR | ME+SA+IT        |            |
| <i>Arnebia decumbens</i>                              | Boraginaceae    | SD, IP     | SA+IT           |            |
| <i>Silene colorata</i> var. <i>oliveriana</i>         | Caryophyllaceae | SD, IR     | ME              |            |
| <i>Astragalus caprinus</i>                            | Leguminosae     | ND         | SA              |            |
| <i>Hyoseris scabra</i>                                | Compositae      | ND         | ME              |            |
| <i>Brachypodium distachyum</i>                        | Gramineae       | ND, IR     | ME+SA+IT        |            |
| <i>Herniaria hirsuta</i>                              | Caryophyllaceae | ND, IR     | COSM            |            |
| <i>Hippocrepis cyclocarpa</i>                         | Leguminosae     | ND, IR     | SA              |            |
| <i>Ononis reclinata</i> var. <i>minor</i>             | Leguminosae     | ND, IR     | ME+SA+IT        |            |
| <i>Rumex vesicarius</i>                               | Polygonaceae    | ND, IR     | ME+SA+SU        |            |
| <i>Crucianella aegyptiaca</i>                         | Rubiaceae       | ND, IR, IP | ME+SA           |            |
| <i>Astragalus asterias</i> subspecies <i>radiatus</i> | Leguminosae     | RF         | ME+SA+IT        |            |
| <i>Lotus arabicus</i>                                 | Leguminosae     | RF         | TR              |            |

The habitats are: CD: coastal dunes, SM: salt marshes, SD: saline depressions, ND: non-saline depressions, IR: inland ridges, IP: inland plateaux and RF: rain-fed farms. The abbreviations of global distribution (i.e. floristic categories) are: ME: Mediterranean, COSM: Cosmopolitan, SA: Saharo-Arabian, TR: Tropical, SU: Sudanese, ES: Euro-Siberian and IT: Irano-Turanian.

## 4. Noteworthy Species

### 4.1 INVASIVE SPECIES:

Invasive species differ temporally, in their mode of introduction, and in the degree of their establishment in various artificial, semi-natural or natural cenoses (Simpson 1932, Drar 1952, Walter 1971, El-Hadidi & Kosinova 1971, Täckholm & Boulos 1974, Hejny & Kosinova 1977). Four species (*Cynodon dactylon*, *Aster squamatus*, *Artemisia monosperma* and *Potamogeton pectinatus*) have begun to invade the Omayed Biosphere Reserve as a result of recent human impact. *Cynodon dactylon*, although not recorded in this region before 1980, is now inhabiting non-saline depressions and rain-fed farms (Abdel Razik 1976, Shaltout 1983). *Aster squamatus*, introduced from Latin America and first recorded in Egypt in the early 1970s, occurs rarely in saline depressions and is now completely naturalized and considered one of the most widespread weeds in

Egypt (Boulos & El-Hadidi 1994). *Artemisia monosperma*, a rare species in this habitat ten years ago, has started to invade the non-saline depressions found along the Khashm El-Aish ridge (in close proximity to the core area of the biosphere), where it is now a dominant noteworthy species. One of the submerged hydrophytes, *Potamogeton pectinatus*, is found in the new irrigation canal in this region. It is tolerant to wide salinity variations but has a tendency towards better growth in slightly brackish water (Aleem & Samaan 1969).

### 4.2 ECONOMICALLY IMPORTANT SPECIES:

One hundred and twenty-nine species (78 perennials and 51 annuals) possess at least one characteristic contributing to a potential or actual economic use. They represent 51.4 percent of the total recorded species. Grazing, medicinal and human food uses are the more common, but timber use is not apparent in this area. Twenty-two of these species are considered multipurpose species, as they have several economic uses (see Table 3 below).

Table 3: Multipurpose species in the Omayed Biosphere Reserve.

| Species                           | Family         | Habitat                   | Uses           |
|-----------------------------------|----------------|---------------------------|----------------|
| <i>Artemisia herba-alba</i>       | Compositae     | All habitats except CD,RF | GR, FU, ME, HF |
| <i>Atriplex halimus</i>           | Chenopodiaceae | CD, SD, ND, IR            | GR, ME, HF, OT |
| <i>Deverra tortuosa</i>           | Umbelliferae   | All habitats              | GR, ME, HF, OT |
| <i>Alhagi graecorum</i>           | Leguminosae    | SM                        | GR, FU, ME, HF |
| <i>Emex spinosa</i>               | Polygonaceae   | All habitats except SD    | GR, ME, HF     |
| <i>Anabasis articulata</i>        | Chenopodiaceae | All habitats              | GR, FU, OT     |
| <i>Ifloga spicata</i>             | Compositae     | All habitats              | GR, ME, OT     |
| <i>Malva parviflora</i>           | Malvaceae      | All habitats              | GR, ME, HF     |
| <i>Phragmites australis</i>       | Gramineae      | RF                        | GR, FU, ME, OT |
| <i>Panicum turgidum</i>           | Gramineae      | IP                        | GR, ME, HF, OT |
| <i>Retama raetam</i>              | Leguminosae    | CD                        | GR, ME, HF, OT |
| <i>Rumex vesicarius</i>           | Polygonaceae   | ND, IR                    | ME, HF, OT     |
| <i>Salsola kali</i>               | Chenopodiaceae | SD, SM                    | ME, HF, OT     |
| <i>Artemisia monosperma</i>       | Compositae     | All habitats except SD    | GR, ME, OT     |
| <i>Arthrocnemum macrostachyum</i> | Chenopodiaceae | SM, SD                    | GR, FU, OT     |
| <i>Asphodelus ramosus</i>         | Liliaceae      | All habitats              | GR, ME, OT     |
| <i>Colchicum ritchii</i>          | Liliaceae      | CD, ND, IR, IP            | ME, HF, OT     |
| <i>Cynodon dactylon</i>           | Gramineae      | All habitats              | GR, ME, OT     |
| <i>Halocnemum strobilaceum</i>    | Chenopodiaceae | SM, SD                    | GR, FU, OT     |
| <i>Sarcocorinia fruticosa</i>     | Chenopodiaceae | SM, SD                    | GR, FU, OT     |
| <i>Sonchus oleraceus</i>          | Compositae     | ND                        | GR, ME, HF     |
| <i>Thymelaea hirsuta</i>          | Thymelaeaceae  | All habitats              | GR, ME, HF, OT |

The habitats are: CD: coastal dunes, SM: salt marshes, SD: saline depressions, ND: non-saline depressions, IR: inland ridges, IP: inland plateau and RF: rain-fed farms. The economic uses are: GR: grazing, FU: fuel, ME: medicinal use, HF: human foodstuffs and OT: other uses.

#### 4.3 COMMUNITIES

The distribution of plant communities in the Omayed Biosphere Reserve is linked primarily to physiographic variations (Ayyad & Le Floch 1983). Forty-one plant communities have been identified in the reserve: eight in coastal sand dunes (Ayyad 1973, Ayyad & El-Bayyoumy

1980), four in non-saline depressions (Ayyad 1976), three in rain-fed farms (El-Hadidi & Ayyad 1975), four in salt marshes, eight in saline depressions (Ayyad & El-Ghareeb 1982), eleven in inland ridges (Ayyad & Ammar 1974), and three in inland siliceous deposits (El-Ghonemy & Tadros 1970, Shaltout & Ayyad 1994). See Table 4 below.

Table 4. Distribution of Plant Communities in the Micro and Main Habitats of the Omayed Biosphere Reserve.

| Plant Community                                                                                                                                                                                   | Micro-Habitat                                  | Main Habitat              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------|
| 1- <i>Ammophila arenaria</i><br>2- <i>Euphorbia paralias</i>                                                                                                                                      | Young, less stabilized dunes                   | Coastal sand dunes        |
| 3- <i>Crucianella maritima</i><br>4- <i>Ononis vaginalis</i><br>5- <i>Pancreatium maritimum</i><br>6- <i>Elymus farctus</i><br>7- <i>Echinops spinosissimus</i><br>8- <i>Thymelaea hirsut</i>     | Old stabilized dunes                           |                           |
| 9- <i>Anabasis articulata</i>                                                                                                                                                                     | Sandy soils with low calcium carbonate         |                           |
| 10- <i>Zygophyllum album</i>                                                                                                                                                                      | Soils with high CaCO <sub>3</sub> and salinity |                           |
| 11- <i>Plantago albicans</i>                                                                                                                                                                      | Soils with low salinity                        |                           |
| 12- <i>Asphodelus ramosus</i> - <i>T. hirsuta</i>                                                                                                                                                 | Fine-textured soils                            |                           |
| 13- <i>Chrysanthemum coronarium</i><br>14- <i>Arisarum vulgare</i>                                                                                                                                | Barley fields                                  |                           |
| 15- <i>Launaea resedifolia</i>                                                                                                                                                                    | More compact and relatively saline soils       | Rain-fed farms            |
| 16- <i>Sarcocorinia fruticosa</i><br>17- <i>Cressa cretica</i><br>18- <i>Atriplex halimus</i><br>19- <i>Arthrocnemum macrostachyum</i>                                                            | High salinity and shallow water table          |                           |
| 20- <i>Suaeda vera</i><br>21- <i>Zygophyllum album</i><br>22- <i>Limoniastrum monopetalum</i><br>23- <i>Salsola tetrandra</i><br>24- <i>Aeluropus lagopoides</i><br>25- <i>Frankenia revoluta</i> | High salinity and deep water table             | Saline depressions        |
| 26- <i>Atriplex halimus</i><br>27- <i>Anabasis articulata</i>                                                                                                                                     | Low salinity and deep water table              |                           |
| 28- <i>Thymus capitatus</i><br>29- <i>Globularia arabica</i>                                                                                                                                      | Rocky sites with low moisture availability     | Inland ridges             |
| 30- <i>Asphodelus ramosus</i><br>31- <i>Herniaria hemistemon</i><br>32- <i>Plantago albicans</i><br>33- <i>Thymelaea hirsut</i>                                                                   | Deep soil with high moisture                   |                           |
| 34- <i>Noaea mucronata</i><br>35- <i>Echinops spinosissimus</i><br>36- <i>Helianthemum lippii</i><br>37- <i>Scorzonera undulata</i><br>38- <i>Deverra tortuosa</i>                                | Sites of medium rockiness and moisture         |                           |
| 39- <i>Moltkiopsis ciliata</i><br>40- <i>Artemisia monosperma</i><br>41- <i>Convolvulus ianatus</i>                                                                                               |                                                |                           |
|                                                                                                                                                                                                   |                                                |                           |
|                                                                                                                                                                                                   |                                                |                           |
|                                                                                                                                                                                                   |                                                |                           |
|                                                                                                                                                                                                   |                                                |                           |
|                                                                                                                                                                                                   |                                                | Inland siliceous deposits |

## 5. Suggested Further Studies

Further studies in the Omayed Biosphere Reserve should include:

1. The completion of the checklist of flora, particularly annual species that may appear during the rainy season and disappear during the dry season. This should include identification of genetic diversity, such as subspecies, varieties and ecotypes.
2. The drawing up of exact location maps for the endemic, rare and threatened species. This will be helpful in designing any conservation plan to rehabilitate their habitats.
3. An assessment of plant communities in the entire area of the reserve (not only along the transect that passes through Omayed village).
4. An estimation of standing crop phytomass and primary production in the major habitats, in order to assess the carrying capacity of this region.
5. Evaluation of nutritive values of the palatable grazed species.
6. The establishment of a record of the phenological sequence of the recorded species, particularly the endemic, rare and threatened species.
7. An assessment of the regeneration capacity of populations of particular noteworthy, rare and threatened species in terms of natality, mortality, survival, and growth rates. Means of propagation for some of these species (either by seeds or vegetatively) should be identified and an assessment of the requirements of seed germination and seedling growth included.

## 6. Management and Conservation of the Omayed Biosphere Reserve Area

Suggested Measures:

- The construction of tourist resorts on the coastal ridge along the whole Mediterranean region in Egypt should cease.
- The implantation of rain-fed plantations in proximity to the core area, while controlling plantations in the transition zone should be prevented.
- The reserve's management team should be strengthened, in particular by increasing the number of rangers to enforce conservation regulations in the biosphere reserve.
- Periodic repairs should be made to the fence surrounding the core area.
- Grazing rotation should be applied to combat overgrazing.

- Quarrying activities inside the reserve should be stopped.
- Cooperation should be strengthened between the reserve's management team and the local inhabitants and related administrations in the Matrouh Governorate.
- The reserve should be put on the ecotourism map of the region.
- A nursery should be constructed for endangered species and those of wide economic use (e.g. highly palatable species and medicinal plants).
- The recently constructed canal should be filled with water. This will transform vast areas of the reserve from natural to arable land. This problem needs to be addressed by the Egyptian Environmental Affairs Agency (EEAA) and Egypt's Ministries of Agriculture and Irrigation.
- Another consideration involves the annual international Shining Star Manoeuvre. The EEAA and Egypt's Ministry of Defense should ensure that this manoeuvre is carried out at the fringes of the reserve.

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# 5

## A Transitional Rehabilitation Belt from the South Moroccan Atlantic Coast to the Sahara

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North Africa is remarkably defended by the great Atlas mountain range, stretching from the west to the east for almost two thousand kilometres across Morocco, Algeria and Tunisia and isolating, to their north, the only truly Mediterranean climate on the sea's southern coast.

The southern slopes of the Atlas mountains fall almost immediately to the Sahara Desert, the largest hot desert in the world. Where breaks occur in the mountain range, in Libya and Egypt, the Sahara can be felt almost to the Mediterranean shore. As in other dry countries, this mountain range represents a major component of the area's advantageous bio-climate. This exceptional geological configuration seems to be a key factor in combating desertification, and is used to good effect in the region by a true arid civilization, itself achieved through human communities living in perfect symbiosis.

The effect of this protective mountain range combined with the influence of the Atlantic Ocean can be seen to most effectively counter the dryness of these latitudes in Morocco, which presents almost the complete range of Mediterranean climatic features. In northern Morocco, all bioclimatic levels, from arid to humid (Emberger 1955, Sauvage 1963), and as many plant stages, from infra-Mediterranean through to glacial oro-Mediterranean (Emberger 1971, Benabid *et al.* 1999) are found in the High Atlas, the Middle Atlas and the Rif, the highest and most extensive of the North African Atlas and Tellian Ranges system. This region has the most extensive and well represented Mediterranean biotopes in the dry latitudes.

To the south of the Atlas the implications are still more remarkable, particularly in terms of the mountains' operating as a barrier protecting against desertification processes. Rather than immediately giving way to the Sahara, as we see to the south of the Saharan Atlas in Algeria, in Morocco we encounter two types of intermediate bio-climates. The first, to the west, is exceptional in every way; it provides the necessary conditions for the distribution of the argan tree. The second bio-climate constitutes a Pre-Saharan zone that acts as a buffer ahead of the actual desert (Fassi 2001).

The western region is the only area in which a typically Mediterranean climate has been able to successfully cross the Atlas range to the Saharan side, a result of its being doubly protected — the Grand Atlas is reinforced by the existence of an Anti-Atlas, isolating the Souss Plain from the direct effects of the Sahara. The Souss Plain, bordered by the High Atlas Range to the north and the Anti-Atlas to the south, opens onto the Atlantic and the cold current of the Canaries to the west. It profits from the favourable Macaronesian coastal climate that, further to the south, along the Atlantic edge of the Sahara Desert, contributes to a littoral strip of moderated Saharan climate.

The combination of these exceptional factors has led to the conservation of the argan tree, a unique remnant of tropical paleoclimates (Fassi 1999). The argan tree has disappeared elsewhere in the world, although it has proved to be a valuable living material capable of combating the aggressive onslaught of the desert. No other tree of comparable quality is able to support real forests, in the Mediterranean sense of the term, in areas of less than 30° latitude and with an the average rainfall of as low as 150 mm. Otherwise it behaves exactly as any other Saharan species, becoming riparian at less than 27° North, as still seen in the Bas Draa and the Sakiet el Hamra Valley. These latitudes are the most equatorial, on the western facades of northern hemisphere continents, in which forest species have been able to venture into and reclaim the desert.

Southeast of the High Atlas, the region between Ouarzazate and Er Rachidia and as far southeast as the perimeter of the true desert still has a chance to survive naturally. With an average rainfall of only about one hundred millimetres — equivalent to that of much of the Sahara — the natural resources regularly provided by the mountains have made this low country an advanced biotic strip, representative of the Moroccan Presahara, where regular and frequent oases support a fairly high local population. It does not, however, benefit from any effective structural protection. The Anti-Atlas, which averages almost two thousand metres to the west of

here, diminishes in the Saghro region and then rapidly disappears altogether.

The true wealth of the region, as for the Souss area, lies in its hydrological resources, which draw their source from the perennial tributaries of the High Atlas. This is the only area of such fertility and with such a regular supply of water along the entire northern periphery of the Sahara. Unlike the Souss, however, a good year is not necessarily determined by rainfall in the defined area but, more importantly, by the quantity of water falling on the southern flanks of the High Atlas. Arable land is only available where irrigation is provided by mountain rivers or underground resources fed by upstream sources. It is interesting to note that all of the water sources in this desert region are entirely renewable and fully provided within the same political boundaries. This hydrological situation, advantageous from a natural and a legal standpoint, is practically inexistent elsewhere in the Sahara and around its borders (*Ressources en eau du Maroc* 1977; OSS-UNESCO 2001).

Nonetheless, moving east, aridity increases quite rapidly. The pattern is further confirmed by the successively decreasing size of the three relatively perennial river networks through which the water from the Atlas mountains is spread towards the heart of the Sahara.

The Draa River, under normal conditions, was once able to provide a continuous superficial water supply penetrating deep into the Sahara over a distance of two hundred kilometres south of the Atlas range. From the Mhamid elbow, the river, which is now barely temporary, still provides water around twice every ten years, flowing over eight hundred kilometres to reach the Atlantic Ocean. Between the river elbow and the Great Hamada, the diminishing water supply can be measured by the disappearance, during the 1970s, of the vast endoreic area commonly known as the Iriqui Lake. This luxuriant and hydromorphic area extended well into the Sahara and was reputed for its valuable biodiversity and its large population of pink flamingos.

Further to the east, the perennial reach of the Ziz and the Guir Rivers is on average only half as long as that of the Draa, and both are resolutely more Saharan. The hydrological legacies of the two *wadis*, which become intermittent and underground to the south of the Tafilalet region, feed small tributaries and the Algerian oases right up to the Tassili and Hoggar systems, situated deep in the heart of the Sahara.

It is even clearer in the oasis region than in the Souss area that the lowlands alongside the desert are almost entirely reliant on the healthy state of the mountains for their major natural resources. This is particularly true for water resources but also applies to soils, as an average annual precipitation of less than three hundred millimetres (Gaussen *et al.* 1958) is insufficient for the development of productive soils *in situ*, and

these must be carried in from the Atlas mountains by surface waters.

The vegetation here is perfectly adapted to its harsh environment. The forests of the southern slopes of the High Atlas, while often very degraded, represent nevertheless the true masterpiece of the natural resources these mountains provide. Far-reaching rehabilitation projects are planned for these forest resources, which are essentially made up of green oak (*Quercus rotundifolia*), thuya (*Tetraclinis articulata*), juniper (*Juniperus phoenicea* and *Juniperus thurifera*), and even mountain argan to the west (Boudy, 1948–58).

In the dry lowlands, the most remarkable forest species is the argan tree (*Argania spinosa*). In addition to its intrinsic protective qualities it also bears fruit: it is often nominated as an ideal multi-use species (M'hirit *et al.*, 1998). Extremely endemic, the argan is found only in the area between the Siroua and the Atlantic Ocean; the more common forest type, at least, seems unable to penetrate further than two hundred kilometres from the coast. Beyond this, the Saharan acacia (*Acacia raddiana*) takes over, as it is capable of surviving intense drought, while the tamarix manages to survive on the often extremely concentrated brackish water that is frequently the only source of water available in arid environments.

Similar to the date palm of the oases, the argan tree is a species that offers a variety of uses. It is a quality oil-seed plant whose oil can be used for gastronomic, cosmetic, or medicinal purposes. The nut, pulp, and leaves provide sub-products used for cattle fodder. The exceptionally dense wood is a precious, sought-after fuel. The soil under the trees can serve as a fertile and protected area for crops, and the branches and leaves provide an original and picturesque “perched” grazing ground for goats.

As is often the case with multi-use species, an “argan culture” has developed, comparable to the “arid culture” of the oases. Obviously, though, a civilization must work towards its continuity and evolve in harmony with its environment. Unfortunately, the twentieth century failed on both accounts. Agadir, the capital of the Souss, is currently undergoing the fastest urban expansion in the country, equal only to that of Casablanca. With its network of suburbs and satellite towns, its water-intensive activities — such as the booming luxury and mass tourism market (Berriane M. 1992) — and the large-scale development of speculative modern, irrigated agricultural endeavours, Agadir is seeing an extensive reclamation of fertile land, coupled with an unrestrained consumption of vital natural resources. The argan tree is obviously under considerable pressure to demonstrate its economic value if argan plantations are to overcome such competition.

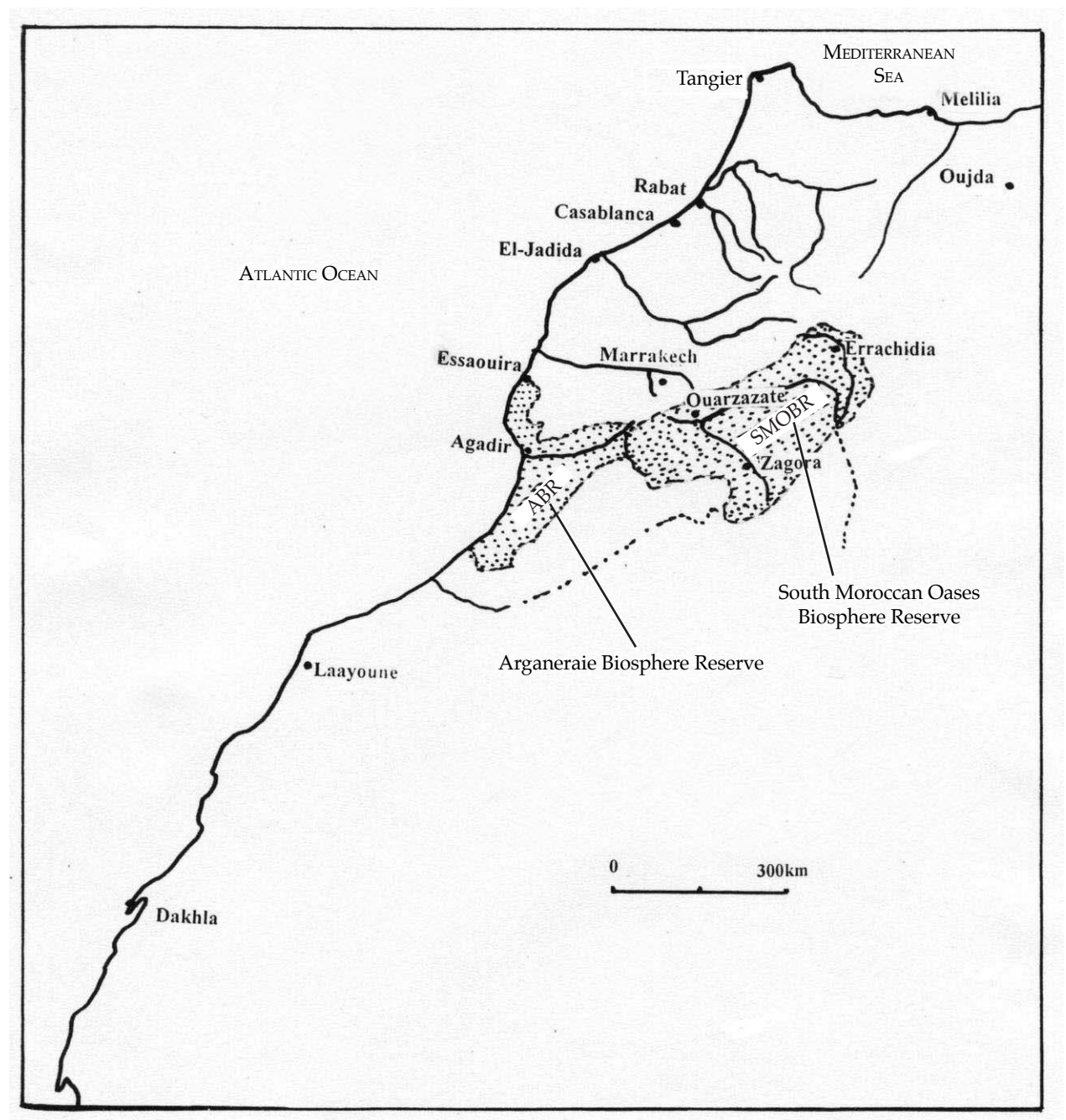
Loss of the argan would perhaps be acceptable if the price to pay was limited to the disappearance of one of the last remaining plain forests in North Africa, one that

extends up to the snow limit and down to the Saharan fringes; an exceptional forest that is also the southernmost in North Africa. But the argan tree's exceptional attributes also demonstrate its extraordinary capacity to protect the environment against desertification in the strongest sense of the term: environmental sterility.

It is always difficult initially to measure the progression of a desertification front in terms of sand accumulation, as by definition, windblown desert sands are constantly shifting. As simple it is to demonstrate changes in sand accumulations, it is extremely complicated to prove that new sands have formed, rather than just a shifting of the same sandy configuration. However, in the Souss Plain this problem is resolved. Physically separated

from the desert by the Anti-Atlas range, there is no possible direct Aeolian contribution of sand from the Sahara. Beyond the perfectly identifiable coastal dunes, all the dunes of the plain's interior are suspected to be the result of local soil erosion. The widening of the group of sand dunes in the region of Biougra, at the centre of the plain, demonstrates quite clearly the link between Mediterranean soils becoming degraded as a result of clearing and an increased vulnerability to wind erosion. Recent terrestrial encroachment by these sands, which have reached the edge of the modern farms near the *wadis*, illustrates the desiccation of water sources, the deepening of underground reserves, the retreat of the argan, and significant devastation of soils.

Figure 1: Biosphere Reserves in Morocco



Neither is it simply a question of losing a characteristic element of the environment (the forest), or seeing the deterioration of a natural resource (the argan tree), either of which might be weighed against the serious economic situation faced in this region. Instead, a number of physiological factors are threatening, and their attrition is leading directly to a deterioration of the quality of the Souss Plain: from a Mediterranean arid or even semi-arid site to one that is resolutely Saharan!

The twentieth century has been even more devastating in the oasis region. The human culture of the oases, the most closely linked to natural water resources in the world, is held together by extreme resourcefulness and human endeavour. It is extremely difficult for such a culture to make compromises to meet imported ideals that are generally poorly adapted to their situation, without selling themselves short and limiting their capacity to endure perennially.

Oases consist of, first and foremost, a very specialized organization and management of space, with distinct zones for agriculture, habitation and livestock. The oasis river macrosystem is necessarily porous, allowing the water provided by the mountain to be used and recycled multiple times along its course. This system feeds numerous series of biological defences that extend deep into the Sahara — and are precious in assuring the survival of the Presahara. The beautiful and biologically luxurious habitat surrounding the Iriqui Lake is a striking example of what is at stake. Since the dam at Ouarzazate impeded the free circulation of water in 1972, the Iriqui has become a vast and desolate sandy desert.

On top of this, the modern urban centres that were introduced to Morocco in the 1920s, such as Ouarzazate, Er Rachidia and Zagora, resulted in an uncontrolled consumption of natural resources, particularly water, which proved catastrophic. They have destabilized the ksouran's habitat: once admirably adapted to the Saharan environment, it is now in a tenuous situation. The use of electric pumps has become considerably more widespread, further devastating groundwater reserves. Although admittedly far easier to use than the traditional *khetaras*, these underground irrigation systems remain the most suited to hot deserts that lie below a mountain range.

The sophisticated traditional drainage systems are also threatened by uncontrolled Aeolisation, leading to the decline of life forms and the submerging of barely thriving settlements through widespread sand encroachment. The arid culture was ingenious in producing these vital watercourses. In doing so, it developed a biological defence which, in the past, was the backbone of the caravan system of commerce.

Once again, it is an exorbitant price to pay for convenience. If the present situation continues, it will directly lead to the depletion of strategic natural resources and the total

collapse of life forms in the region. We are witnessing the complete disappearance of one of the final magnificent examples of the Presaharan zone. The loss is not only regrettable in terms of the region's biological heritage, but also because of the bioclimatic imbalance it would provoke on a global scale, resulting in the total eradication of the entire Presaharan zone, with all the consequences that this implies.

The search for solutions goes well beyond the means a single region or country has at its disposal. The argan tree's area of distribution (almost three million hectares) and most of the Moroccan Presaharan zone (over eight million hectares) have been declared Biosphere Reserves — the Arganeraie Biosphere Reserve (*Réserve de Biosphère de l'Arganeraie*, listed in 1998) and the South Moroccan Oases Biosphere Reserve (*Réserve de Biosphère des Oasis du Sud Marocain*, 2000). The South Moroccan Oases Biosphere Reserve also includes a World Heritage Site listed by UNESCO (Ksar Ait Ben Haddou). Despite the obvious geographic differences, their contiguous position and common function in combating desertification form a transitional rehabilitation belt from the Atlantic coast to the Sahara.

The major challenge the two biosphere reserves face is to propose an alternative to the growing and persistent threat of desertification. The aim is clear: to maintain the natural productivity of the mountains and to ensure the valleys are sufficiently fertile so as to support life as far into the desert as possible.

## Conclusion

The changes that occurred over the last century were the type of practically irreversible metamorphoses that are often summed up by the expression: "You can't fight progress". Nevertheless, awareness of an imminent ecological disaster is growing. In North Africa, the desert's close proximity has the advantage of making the effects our actions have on the environment perceptible within a human timescale. The fragility of these ecosystems calls for constant and informed action to check the process of degradation, which otherwise will entail predictable consequences. And in the same way that the arid culture here developed with no regard for political borders, it is fitting now that in the search for rehabilitation the Sahara be considered in its entirety.

Rehabilitation must be across the board. It must integrate the comprehensive restoration of natural forest, steppe, plain and mountain habitats with the more difficult rehabilitation of regional knowledge, by allowing such knowledge to be promoted to the level of science. For this strategy to succeed requires the support of reliable strong points in the Sahara; such as the Moroccan Draa and Tafilalet Valleys, the Mzab region in Algeria, the Ghadamès in Libya and, of course, the Nile system.

More biosphere reserves are needed at the centre of the Sahara, such as at Tassili n'Ajjer in Egypt, and they need to be consolidated by Macaronesian and Sahelian reserves along the Atlantic coast and the southern banks of the Sahara. By following this constructive strategy, the Sahara would be perceived as a second Mediterranean — no longer broken into artificial divisions, it would rediscover its role at the crossroads of civilizations.

From this perspective, the concept of combating desertification becomes clearer. The desert is no longer an external and shapeless enemy. From being once viewed as being spatially anonymous, the end of the conceptual world, the desert began to take shape by acquiring a geographic identity; being given, for example, the name "Sahara" in Northern Africa. It must now be accorded a central role — a role that goes beyond simply the technical considerations of rehabilitating natural resources, as important as these may be — and position itself at the very heart of a vast project for all society.

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# 6 Rehabilitation of the El Dinder Biosphere Reserve in Sudan

*Prof. Hassan A. Musnad, MAB Committee Chairman, National UNESCO Commission, Khartoum, Sudan*

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## Introduction

This report describes the current activities being carried out to rehabilitate Sudan's El Dinder National Park in an attempt to bring it closer to the biosphere-reserve concept. The material contained in this report is a compilation and summary of several expert reports made available to the author by the deputy chairman of Sudan's Man and the Biosphere Programme (MAB) committee, Dr. Moutasim Nimir, who is leading this rehabilitation process.

## 1. El Dinder

El Dinder National Park is suffering from the severe degradation of all of its resources, resulting from a rising farm population and its consequent encroachment on the park (regardless of whether these farms have been approved or not). El Dinder also endures competition for rangelands and other natural resources, and tree-felling in adjacent areas. The park's ecological systems and wildlife have all suffered from the local population's on-going exploitation, as a lack of human and financial resources has prevented Sudan's Wildlife Administration from protecting it effectively. In addition, a lack of environmental awareness and infrastructure has hindered the development of tourism. However, the burning issue is the disdain felt by the local population towards the park and its administration: a situation that has led to the use of firearms and the regrettable killing of guards defending the park.

## 2. The Rehabilitation Project

The rehabilitation project, The Protection and Management of the Ecosystem and Biodiversity in El Dinder National Park, is to span a period of three years. The project is financed by the United Nations Development Programme (UNDP: US \$500,000), the Global Environment Facility (GEF: US \$750,000), and the government of Sudan (the Wilaiat Support Fund) and administered by Sudan's Higher Council for the Environment,

Wildlife Administration and Ministry of Environment and Tourism.

### 2.1 OBJECTIVES

The rehabilitation project aims to involve the local population, those living in El Dinder National Park and in the surrounding areas, by encouraging them to participate in sustainable development and environmental protection activities that are intended at once to protect the park and to improve the livelihood of this local population.

The project will offer alternative, sustainable sources of income (for example, through community forest plantations, fruit-gathering, fishing, tourism, setting up beehives, and establishing cottage industries based on natural resources).

The project's major objectives are:

- Protection and rehabilitation of the ecosystem.
- Protection of biodiversity.
- Protection of wildlife in the park.

### 2.2 EXPECTATIONS

- a) Basic information on the flora and fauna of the park will be collected, as well as socio-economic information on the local population. The park boundaries and vegetation and hydrological maps will be revised.
- b) The Wildlife Administration will consolidate its human resource capacity in the park and improve transport, communication and training of personnel for effective park management.
- c) Research and studies will be carried out to conserve ecosystems and to protect endangered species.
- d) Actions will be geared towards involving local communities and formulating sustainable development activities that improve living standards, in an effort to improve environmental awareness and win local support to protect the park. This may include the provision of services such as water, education and forest plantations.

- e) Surveillance and protection patrols will be strengthened.
- f) Cooperation and coordination with the three Wilayas will be established, to improve the rangelands for pasture and to provide water for animals in adjacent areas of the park, thus preventing pastoralists from entering the park for water and fodder.
- g) Tourist accommodation capacity and the promotion of tourism generally will be improved.
- h) A plan will be formulated outlining several future projects for international community funding.

### 2.3 TARGETED AREAS

The rehabilitation project aims to support and assist the Sudanese Wildlife Administration in El Dinder National Park and in other Sudanese parks in developing management plans. The project also targets the local population in the area of the park and all those who are interested in nature and wildlife in Sudan, as well as research groups from universities and research centres.

The project endeavours to establish and promote bilateral relations with regional and international organizations interested in biosphere reserves, organizations such as UNESCO, the World Conservation Union (IUCN) and the Food and Agriculture Organisation of the United Nations (FAO).

### 2.4 STRATEGY

The strategy of the El Dinder National Park rehabilitation project is based on the following guidelines:

- To contribute to the welfare of the local population by developing and providing alternative and sustainable resources for improving living conditions.
- To fully involve the local population in the protection of the park, by raising environmental awareness through their local leaders.
- To combine cooperative efforts among the three Wilayas sharing the park.
- To increase training and build capacity at the Wildlife Administration.
- To highlight the importance of infrastructure and biodiversity.

### 2.5 REQUIREMENTS FOR PROJECT SUCCESS

The success of the Protection and Management of the Ecosystem and Biodiversity in El Dinder National Park project relies on attaining the right conditions in the three Wilayas sharing the park. This calls for:

- Conflict resolution in land-use planning and natural-resource use in the three Wilayas,
- A solution to rangeland allocation,
- Political support for El Dinder park and the acknowledgement of its value.

## 3. Current Activities

El Dinder National Park's water resources are currently being assessed. A thorough understanding of water resources will help in managing the use and distribution of water for community use in the park and the surrounding areas. An Ecological Baseline Survey is also being carried out in the park.

This report, dated 2001, is co-authored by the Sudan Wildlife Research Centre and Higher Council for Environment and Natural Resources.

# 7

## Djebel Bou-Hedma Biosphere Reserve in Tunisia: An Example of the Rehabilitation of Degraded Drylands

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### Abstract

More than two-thirds of Tunisia is located in arid and desert areas where average annual rainfall is below three hundred millimetres. Plant cover in this vast area is subjected to various forms of pressure and is consequently suffering the effects of heavy degradation. Over the course of the last century, demographic pressure, combined with pastureland cropping, has accelerated the degradation process. These intrinsic mutations of land use have led to a severe drop in the number of original plant formations, and have resulted in different forms of erosion. Some areas have been accorded national park status in order to protect the more representative ecosystems. Bou-Hedma National Park is an example of this, in the upper arid region of the Atlas Mountains separating Central and South Tunisia.

Bou-Hedma National Park has been part of the Man and the Biosphere Programme (MAB) network of reserves since 1977, and part of ROSELT-OSS (the Sahara-Sahel Observatory's Long-Term Ecological Observatories Monitoring Network, or *Réseau d'Observatoires de Surveillance Ecologique à Long Terme du Observatoire du Sahara et du Sahel*) since 1995. The principal objective behind its creation was the conservation of the *Acacia tortilis* subspecies *Raddiana*, a plant heavily affected by human activities. Several research programs have been conducted at Bou-Hedma, notably within the framework of the ROSELT program, which aims to assess ecosystem degradation and study possible rehabilitation measures and the interaction between ecological and socio-economic systems.

Significant results have been achieved, particularly in the field of natural-resource conservation. Nonetheless, activities related to development, important elements of biosphere-reserve objectives, have been relatively neglected. These activities need to be further strengthened in line with the recent Biodiversity Conservation and Protected Areas Management development project, which was negotiated and duly supported by the World Bank as one of the three implementing agencies of the Global Environment Facility (GEF).

### 1. Introduction

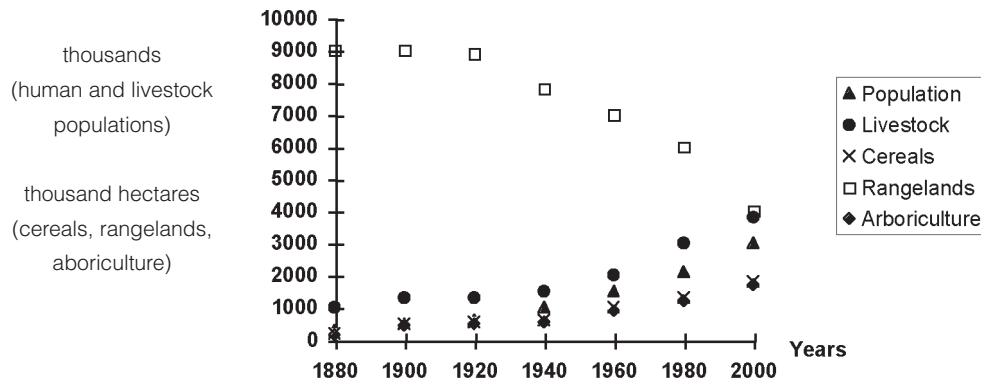
Tunisia covers an area of 16.4 million hectares, two-thirds of which is located in arid (32.2 percent) and desert (42.7 percent) areas characterized by erratic and low rainfall; less than 100 mm for the desert areas and less than 350 mm for the arid areas. In addition, high temperatures together with hot sirocco winds desiccate the remaining sparse vegetation during the summer months.

These pastoral areas present mainly herbaceous and shrubby vegetation. Human and livestock pressure have depleted this fragile environment's trees, which are now generally limited to favourable microzones, such as riverbeds where water runoff accumulates, or mountaintops where rainfall is greater.

As the areas best suited for rangeland in the plains of central and southern Tunisia have been gradually cultivated and used for arboriculture (with olive trees predominating) and cereal crops, which to a variable extent depend on autumnal rainfall, today's rangelands instead tend to be located in desert areas, where rainfall is extremely low, and where crusty soils are observed. Desert rangelands represent 42 percent of Tunisia's estimated 5.5 million hectares of rangelands. Figure 1 identifies the different trends leading to a decrease of rangelands, and illustrates the associated human and animal pressure.

Over the past decade, these rangelands have become degraded due to the increase in livestock numbers and recurrent droughts. In the last four decades, livestock has increased from 1.3 to 3.9 million sheep and from 250,000 to 750,000 heads of goat. About 72 percent of the sheep and 81 percent of the goats are in the central and southern part of the country (World Bank 1995). From 1971–1992, approximately one million hectares of good rangeland was converted for tree planting and cereal crop activities. Along with this regression, livestock numbers increased almost threefold — resulting in a dramatic depletion of plant cover. Today, these rangelands support 10 to 25 percent of livestock needs, compared with 65 percent

Figure 1: Human and livestock pressure on rangelands (Nefzaoui 1997)



in 1960. There is an urgent need to develop appropriate techniques to satisfy the increasing demand for feed by improving productivity of rangelands and diversifying feed resources.

In addition to the economic problems this situation presents, environmental and ecological issues need to be taken into consideration, as rangeland degradation invariably augments biodiversity erosion and other desertification processes and ecological imbalance. Several instruments have been considered and measures have been taken to limit ecosystem degradation and initiate rehabilitation. An example of an effective solution is the establishment of a network of protected areas that not only preserves representative samples of important ecosystems but also develops methods and tools for biodiversity recovery in protected areas. In this way, observatories and referential zones become centres for degraded land rehabilitation and for natural-resources management. Bou-Hedma National Park, which is also a biosphere reserve, is one the first sites in Tunisia in which such activities have been implemented.

## 2. Djebel Bou-Hedma Biosphere Reserve

### 2.1 LOCATION AND BRIEF DESCRIPTION

Bou-Hedma Biosphere Reserve is located in the southern part of the Saharan Atlas Mountains, with an altitude of 840 meters at its highest point. Three geomorphologic zones can be identified:

- An eroded mountainous zone with gullies and crusted soils;
- A piedmont zone of glacis with gentle slopes;
- A plain with alluvium, clay-alluvium and sandy deposits, where *Acacia tortilis* (subspecies *Raddiana*) can be found.

Approximately four hundred plant species are represented in the park. They reflect typical characteristics of

the flora of arid zones in Tunisia. The biosphere reserve experiences arid, temperate winters with an average rainfall of 220 mm, varying between 150 mm and 300 mm. Eight of the fourteen priority protected plant species in southern Tunisia are found in Bou-Hedma. They comprise:

- Six woody species: *Acacia raddiana*, *Juniperus phoenicea*, *Pistacia atlantica*, *Thymelea sempervirens*, *Tetrapogon villosus*, and *Tricholena teneriffe*
- Two herbaceous species with high pastoral value: *Cenchrus ciliaris* and *Digitaria Commutata*

The fauna is also fairly diversified. Two species worth noting are muffle, *Ammotragus cervia*, and dorcas gazelle, *Gazella dorcas*. Reintroduced species include the Oryx (*Oryx dammah*), the Addax antelope (*Addax nasomaculatus*), and the Mohrr gazelle (*Gazella dama mohrr*).

### 2.2 HISTORY

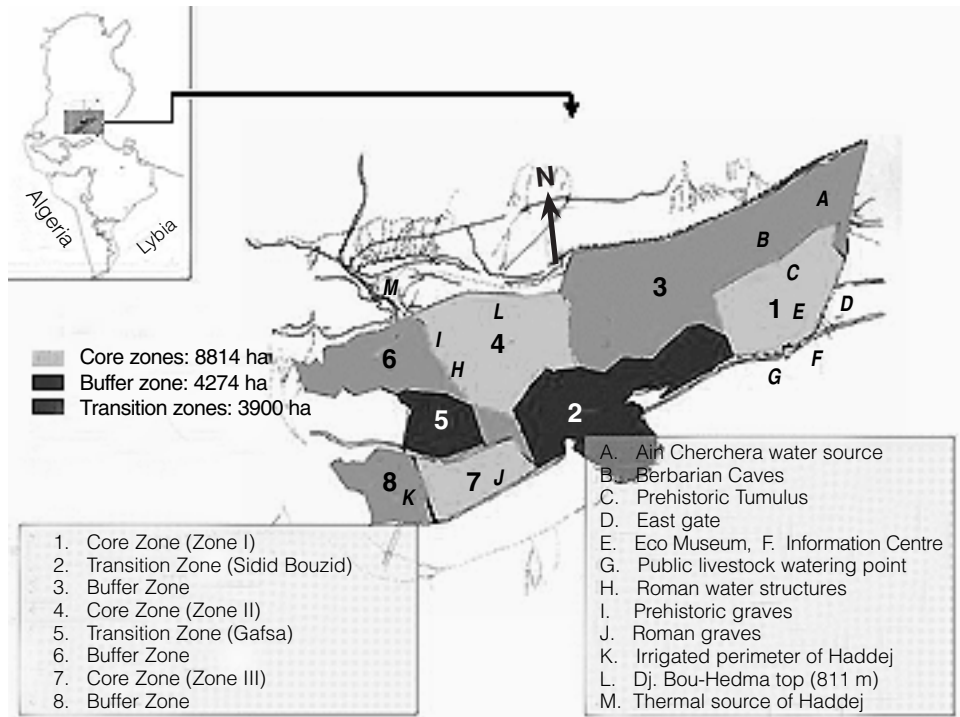
The history of Bou-Hedma Biosphere Reserve dates to 1936, when the need to create a national park to conserve the *Acacia raddiana*-based ecosystem was first proposed. The first protected plots were established in 1957–1958, but it was only in 1980 that national-park status was officially accorded (Decree n° 80-1606 of December 18, 1980). In 1977, the site became part of the UNESCO-MAB network of biosphere reserves, and in 1995 it joined the ROSELT-OSS network.

The reserve totals 16,488 hectares, differentiated into three zones:

- A core zone of 8,814 hectares, made up of 4,500 hectares of plains and piedmonts and 4,374 hectares of mountains.
- A buffer zone of 4,274 hectares, with 3,019 hectares of piedmonts and 755 hectares of mountains.
- A transition zone of 3900 hectares of plains.

The reserve's total population is estimated to be 320 households, or 2440 people, living principally in the transition zone — initially conceived as a “temporary occupied zone”.

Figure 2: Bou-Hedma Biosphere Reserve



### 2.3 RESEARCH PROGRAM

Initially, Bou-Hedma was established to protect the *Acacia raddiana* forest, but its role has been extended to include conservation of the entire ecosystem based on *Acacia raddiana* and the landscape. It is worth noting that until recently, *Acacia raddiana* forest extended over thirty thousand hectares at Bou-Hedma alone. Today, this has decreased to approximately ten thousand hectares, covering the area from the Sahara to Central Tunisia. Moreover, *Acacia raddiana* is the sole *Acacia* species present in the area from southern Sahara to the Middle East, justifying its importance for comparative studies of ecosystems where it is associated (El Hamrouni, 1993).

Wide-ranging and species-rich sets of flora and fauna are associated with *Acacia raddiana*, and specific ecological and landscape characteristics have been observed in central and southern Tunisia (Le Houérou and Le Floc'h, 2001). Bou-Hedma Biosphere Reserve is thus extremely important for the implementation of a national strategy on biodiversity conservation. Several studies and research programs have and continue to be conducted in this zone. Other programs are planned in order to improve knowledge on ecosystems and land use systems (see Table 1, opposite).

Detailed data on vegetation was collected along permanent transects from 1988 to 1992, and is useful for plant-monitoring purposes. Several agronomic and socio-economic studies are also available. Nevertheless, important areas such as a fauna inventory have been overshadowed and need to be explored further.

Among current research programs, the *Institut des Régions Arides* (IRA), within the framework of the ROSELT-OSS network, is conducting activities related to:

- Environmental monitoring, considering land use, climate, soil and vegetation, wildlife, surface water, and socio-economics and land-tenure issues.
- Analysis of data and mechanisms focusing on climate change and human activities that impact on the environment, including ecological systems studies based on *Acacia raddiana* systems functioning.
- Development of agro-sylvo-pastoral decision-making tools: an environmental database, a natural-resources management support program, and biodiversity desertification indicators.

These long-term activities began in 1997. Results have been generally satisfactory, varying in consistence depending on the activity. Collaboration with ROSELT-OSS has included linking the activities at Bou-Hedma to Menzel Lahbib as a reference site. Subjected to much stronger human pressure, Bou-Hedma provides useful information on desertification processes and biodiversity variation. The area monitored stretches from the Bou-Hedma piedmont protected area to the over-degraded sub-littoral alluvial plain.

It is also important to note that Bou-Hedma Biosphere Reserve is one of three Tunisian national parks, which include the Ichkeul and Jbil parks. These national parks will benefit from the GEF-World Bank-funded Biodiversity Conservation and Protected Areas Management project.

Table 1. Studies and research programs conducted at Bou-Hedma

| Items                                                                                                                             | Activities and Inadequacies                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1988–1992 : Exhaustive flora survey and monitoring through permanent transect                                                     | + Monitoring of plant species<br>– Lack of fauna monitoring                                                                                                                                                                                                                                                                                                |
| Since 1977 the IRA / ROSELT-OSS program has been linked to Menzel Lahbib as its reference site                                    | + Environment monitoring,<br>+ Impact of climate and human pressure on ecological system dynamics,<br>+ Development of decision-making tools (indicators of biodiversity and desertification),<br>– Lack of fauna monitoring and insufficient flora monitoring                                                                                             |
| GEF-World Bank program “Biological biodiversity conservation and protected areas management” (new project). Three national parks. | + Infrastructure reinforcement in the reserve and neighboring areas<br>+ Improvement of the reserve’s management,<br>+ Adopting a participatory approach, improvement of development activities including ecotourism,<br>+ Enhancement of ecological monitoring and research activities,<br>+ Promotion of training, information and awareness activities. |

See Table 1 for activities related to the project in the Bou-Hedma Biosphere Reserve.

## 2.4 BIOSPHERE RESERVE FUNCTIONS AND OBJECTIVES

It is fundamental to know to what extent the main functions and objectives of the Bou-Hedma Biosphere Reserve have been achieved.

### Conservation

Bou-Hedma’s natural and cultural diversity have been relatively well preserved. Recovery of the biodiversity of the *Acacia raddiana*-based steppe is expanding, with highly diversified flora and fauna. In addition to the species identified and mentioned earlier, two bird species have been introduced: an ostrich (*Struthio camelus camelus*) and a guinea fowl (*Numidia meleagris*). Two native species, *Ammotragus lervia* and *Gazella dorcas*, need to be noted for their spectacular adaptation to the local environment.

The number of animals in the reserve is increasing, and can thus be considered a success. However, serious problems have arisen with regard to the sustainability of the reserve in terms of feed availability, particularly during drought years when intervention might be recommended. Animal numbers should be appropriate to the carrying capacity of the reserve.

Bou-Hedma’s cultural heritage is also well preserved, with several relics from the Roman Empire and earlier still in good condition.

### Development

The majority of the population live in the transition zone. This was originally designated a “temporally occupied zone” — as it was envisaged that the local population

would eventually move elsewhere, essentially transforming the entire reserve into a core zone. This idea was later rejected and replaced by an ambitious development initiative, a new orientation based on the need to improve the livelihood of the local population to win over their full cooperation in the management of the reserve.

The project has been conceived within the framework of the biosphere-reserve concept, and adopts a participatory approach. The impact of this development effort will go well beyond the park’s boundaries.

Planned activities include improvements to the existing infrastructure (in areas such as roads, electricity, water supply, and telephone connections); augmented education and health facilities; and income-generating diversification (farming, livestock, handicraft, ecotourism, etc.).

### Logistic Functions

The park’s logistic functions incorporate monitoring, research, training and education activities.

A permanent monitoring system has been implemented, notably within the framework of the ROSELT-OSS program. While a significant effort is currently dedicated to monitoring physical factors such as soil, climate, and water, further work is needed in this direction to ensure the entire reserve zone is included. The monitoring of fauna also needs to be revised.

Several research activities are being conducted within Bou-Hedma. The most significant are related to the structure and dynamics of the *Acacia raddiana* steppe and the phenological characteristics and behaviour of *Acacia raddiana* itself. Research has also been carried out on seed germination, seedling production, natural propagation, and nitrogen fixation (Abdallah *et al.*, 1999).

*Figure 3: Acacia raddiana returning to its original habitat from the protected area.*



*Figure 4: Wildlife protection can result in animal numbers exceeding optimum levels for available feed resources*



*Figure 5: The protection of plants has had a remarkable effect on plant diversity, with over four hundred thriving native species .*



While current activities are related to systematic monitoring, studies are needed in areas such as the impacts of climate variation and human pressure, the interaction between the different ecosystem components, the pressure of the fauna within the protected area, and livestock pressure on neighbouring areas.

Environmental education and training, and improved awareness of environmental issues are relatively well pursued. More than half of the park's total visitors (4467), are schoolchildren (1991), students (386) and scientists, (362 Tunisians and 50 foreigners). These figures clearly demonstrate the scientific community's increasing interest in the Bou-Hedma Biosphere Reserve.

## 2.5 ACHIEVEMENTS AND IMPACTS

In dry years, Bou-Hedma can be compared to an oasis among the surrounding degraded and eroded environment, where olive trees grow in natural depressions, benefiting from water-harvesting techniques. These plantations are expanding to pastoral areas, which are heavily degraded due to overgrazing and episodic cereal cropping. The protected area is thus like a sanctuary for natural vegetation and endangered fauna species, conferring to the reserve a major role in arid-zone biodiversity conservation.

The Bou-Hedma Biosphere Reserve is also a favoured site for forest and rangeland species collection and evaluation, as well as research related to arid zones. A good example is the IRA. Located two hundred kilometres south of the reserve, most of its species were collected from the Bou-Hedma Biosphere Reserve.

The central area of the reserve is a reference for the evaluation of vegetation potential and wildlife regeneration. Limited numbers of species have extended to the buffer and transition zones. The agroforestry system relies primarily on *Acacia raddiana*. The local population is encouraged to plant *Acacia raddiana* in the transition zone, yet there has been some reluctance — due to other urgent basic needs and also to its slow-growing character. Attempts to improve rangelands by reseeding *Cenchrus ciliaris* have seen only limited success, due to particularly low rainfall. This is also the main reason why most actions to improve rangelands in Tunisia are based on the use of exotic, fast-growing species like *Acacia cyanophylla*, *Atriplex nummularia* and spineless cacti.

There has recently been renewed interest in local rangeland species in Bou-Hedma. These species include *Periploca levigata*, *Rhus tripartitum*, *Rosmarinus officinalis*, *Ziziphus* and lotus. Multipurpose species such as *Rhus tripartitum* and *Ziziphus lotus*, which can provide wood for fuel, fodder for livestock and fruits for human consumption, should be promoted and expanded to buffer and transition zones, as they can augment local incomes and enhance the welfare of the population.

## 2.6 LOCAL KNOWLEDGE

Can local knowledge help to combat desertification? It is difficult to provide a satisfying answer to this question. It is obvious that the increase in desertification that we have experienced over the last few decades has been generated by a breakdown of the prevailing, fragile equilibrium. This has been compounded by factors such as an rapidly increasing population and the use of inappropriate technologies. Local knowledge becomes insufficient when anthropogenic pressure is too great. In the Bou-Hedma area, it is necessary to use more efficient technologies that take environmental constraints into consideration, though local knowledge should still be taken into account.

Results observed at Bou-Hedma's protected area clearly demonstrate the efficiency of the fallow grazing technique. Other more sophisticated techniques (re-seeding, planting, using fertilizers) are difficult to implement in arid areas, primarily because of climatic constraints such as low rainfall. However, it is evident that the fallow technique may fail in some cases, and that other, more suitable restoring methods may be necessary. These issues are related to two fundamental concepts that are the basic tools for natural-resources management; restoration ecology and landscape ecology.

## 3. Conclusions

Arid-zone rangelands are facing several problems with regard to their institutional, social, economical, and technical management. Over the last fifty years, a marked shift in land-tenure status has taken place in Tunisia, with a noticeable impact on technical and socio-economical issues. These changes are a result of collective rangeland privatisation and the consequent cropping and tree-planting of the best pasturelands. Efforts to improve rangelands in arid areas targeting deferment grazing, reseeding, shrub planting, and fertilizer application appear to be inefficient in such a harsh environment, and appropriate management tools involving users and communities and based on the promotion of local institutions remain probably the most promising solution.

Bou-Hedma Biosphere Reserve is a very good example of a success story of arid-zone rehabilitation. A representative sample of an *Acacia tortilis* (subspecies *raddiana*) based ecosystem has been restored. Remarkable results have been obtained, with the recovery of an *Acacia raddiana*-based steppe forest and confirmation of the presence of more than four hundred plant species in the reserve. Fauna has also recovered, including large mammals and endangered species.

But the achievements obtained within the core zone of Bou-Hedma have had little impact on the transition and buffer zones or the surrounding areas. Development activities are being implemented in these zones, with the

aim of improving the welfare of the local population and their involvement in the planning and decision-making process, so that they can fully benefit from the reserve.

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# 8

## Land Degradation In Namibia: Methodological Approaches of the Biota Southern Africa Project

*Mariam Akhtar-Schuster, Institute for General Botany, University of Hamburg, Germany*

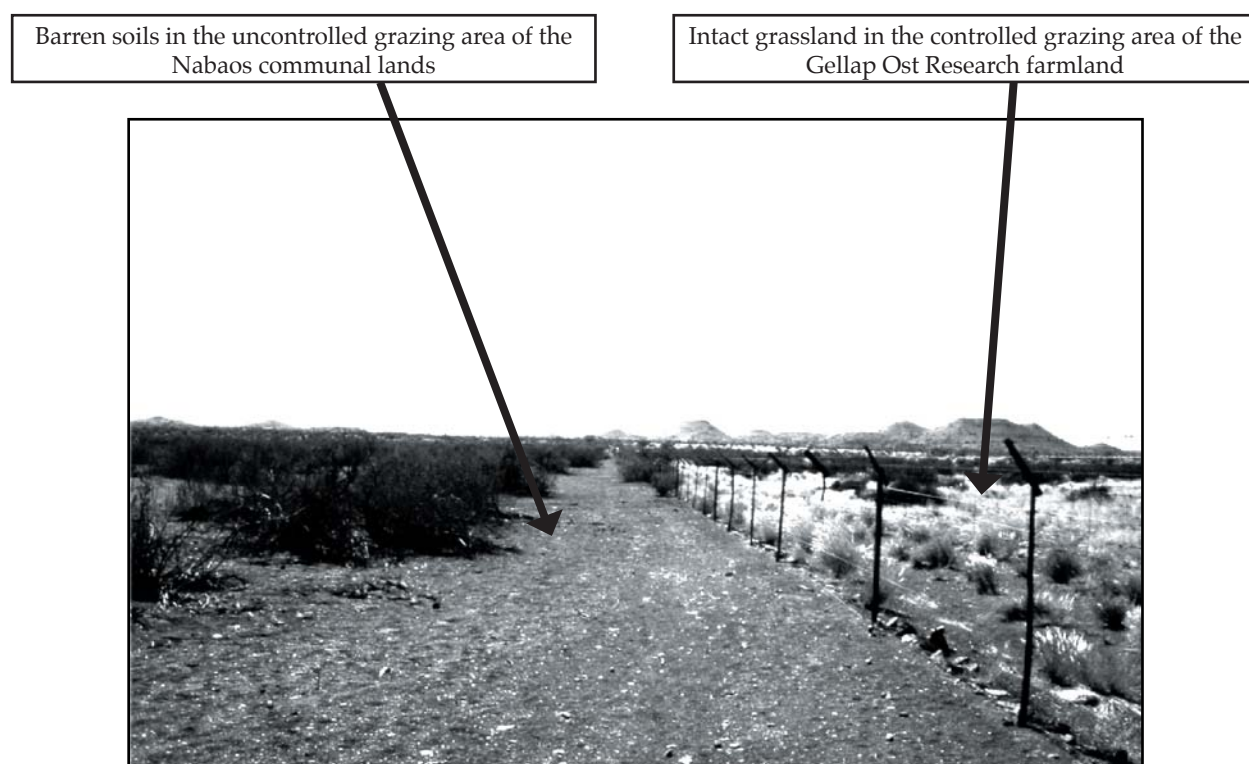
### Introduction

The Biota Africa project is an interdisciplinary co-operative research initiative that analyses changes to biodiversity in Africa. The project initiative is sub-divided into three regional sub-projects that are located in East, West and Southern Africa.

A key concern of Biota Southern Africa is to detect the impact that land use has on the bio-physical environment, and to develop scientifically sound concepts for the conservation and the sustainable utilization of biodiversity in Africa<sup>1</sup>. Ecological indicators demonstrating deficient exploitation of resources, and therefore severe land degradation, have frequently been observed in Namibian

and South African rangelands. In the Nama Karoo region in southern Namibia, for instance, differing land-use intensities have produced a typical “fence-line contrast” in the neighboring research sites of Gellap Ost and Nabaos (see Figure 1). Varying grazing intensities in communal (i.e. open) grazing systems and regulated commercial farming areas have had ocular effects on biodiversity and the regeneration potential of the exploited natural vegetation. To analyze the magnitude of disruptive effects on dryland biodiversity in the study area, an interdisciplinary oriented methodological approach was indispensable.

*Figure 1: A typical fence-line contrast in Southern Namibia, induced by uncontrolled grazing*



## 1. Methodology

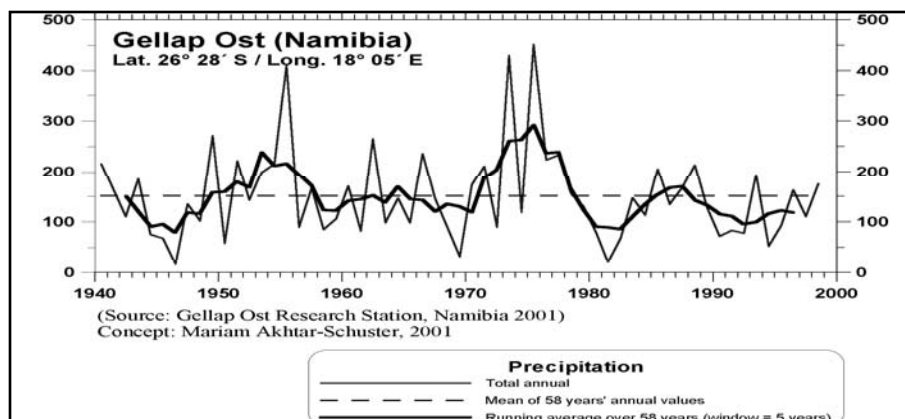
In the Biota Southern Africa project, research on the impact different land-tenure systems have had on the environment is being conducted along the main rainfall gradient, leading from the winter rainfall Cape region to the summer rainfall regions of northern Namibia. Using thirty standardized biodiversity observatories — research areas established along a two-thousand-kilometre-long project transect, each one square kilometre in size — ensures the comparability of field results (see Figure 2).

As part of the Biota Project, one-square-kilometre biodiversity observatories were established in 2001 at the Gellap Ost Research Station and the Nabaos Communal lands, which are both in an area that receives an average rainfall of about 150 mm (see Figure 3). The two observatories are barely 150 metres apart, in identical environments that have been and are still exposed to different land-use intensities and practices. This proximity allows us to distinguish and compare the impact different land-use intensities have on the natural environment.

Figure 2 The BIOTA Southern Africa transect and the location of the Gellap Ost / Nabaos Biodiversity Observatories



Figure 3 Long-term trends at the Gellap Ost Research Station, Southern Namibia

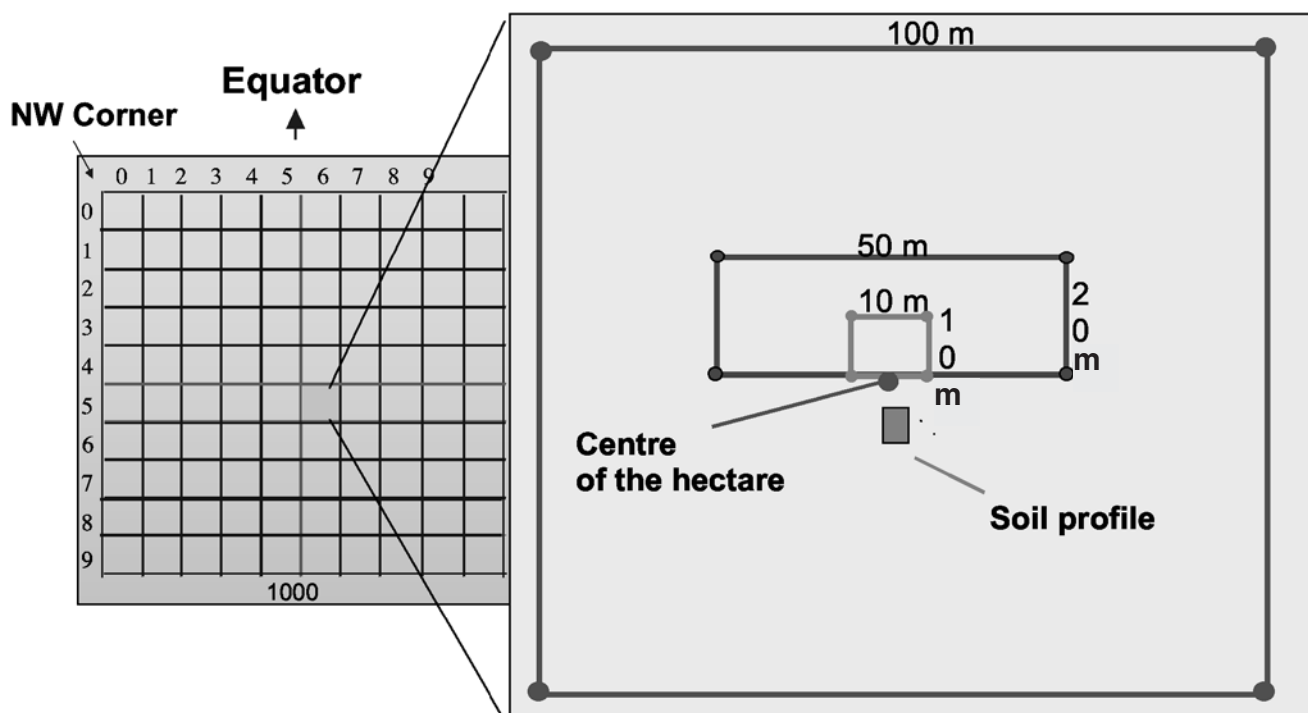


The Biota biodiversity observatories were subdivided into hundred-hectare plots, representing the different habitat types found in the observatories. During the first year of field observations, 2001, plots were randomly selected and the major habitat of each was identified.

Standardised sampling scales (of 0.01, 0.1 and 1.0 hectares) were defined for floristic inventory (see Figure 4) (Jürgens *et al.*, 2001). The species growing within each plot were sampled and identified during the summer rainfall months. Species composition, abundance and coverage readings were documented for the 0.01 and 0.1 hectare plots during the rainy season. To estimate soil seed reserves, vital for the rejuvenation of plant

uncontrolled grazing. An undesirable number of animals (especially goats and donkeys) enter this open access system regularly. Donkeys and some 450 to 500 goats graze unattended on a daily basis in the Nabaos Observatory. The goats are the main source of income for the people of Nuwe Fontein, a small settlement located barely one kilometre to the northwest. The livestock owners interviewed said that they left their animals unattended in the field because they would then graze and browse according to their needs, thus finding the best feed resources for “fattening”. Herders, they said, would on the other hand always try to monitor the animals’ movement.

Figure 4: The Design of a Biodiversity Observatory



cover, soil was sampled from the surface to a depth of five centimetres.

A soil profile was taken five metres south of the centre of each one-hectare plot and sampled for laboratory analyses. The soils were classified according to the *World Reference Base for Soil Resources*, FAO, 1998 (cf. also Gröngroft, Petersen & Miehlich, 2001). VA mycorrhizae spores were measured to assess the impact of land-use intensity (Berndt *et al.*, 2001). Finally, long-term monitoring of the population dynamics of small mammals was initiated in each observatory (Zeller *et al.*, 2001).

## 2. Land Tenure

The unfenced Nabaos Communal Lands are common property resources, and subject to unregulated and

The Gellap Ost Research Station is subdivided into numerous fenced camps. Although even here the animals roam and graze unattended, the number of sheep and cattle that enter a camp and the time spent grazing are strictly controlled. The Gellap Ost biodiversity observatory is located in the 261-hectare Camp B1. The staff at the Research Station carries out regular field observations to discern any signs of overgrazing. If indicator plants are grazed over 75 percent, grazing intensity in the related camp is subsequently reduced for a period of time.

## 3. Preliminary Findings

Based on soil investigations carried out in the two neighboring biodiversity observatories, two one-hectare plots (Plot 62 at Gellap Ost and Plot 31 at Nabaos) with

comparable soil properties and topography and thus similar abiotic features were selected to compare the effects of the different grazing intensities at Gellap Ost and Nabaos. Vegetation mappings revealed marked differences between Nabaos and the Gellap Ost biodiversity observatory. A decline in species richness could be documented in the low-growing life-forms in the Nabaos observatory (see Figures 5a and b). Herbs, grasses and low shrubs are permanently exposed to maximum grazing pressure.

A comparison of species richness was made in fifteen-hectare areas in both observatories. Field surveys showed that only half as many species were recorded at Nabaos as at Gellap Ost (Figure 6). The salt content in the Nabaos soils occasionally showed slightly higher rates than at

Gellap Ost, generally between 6 and 196  $\mu\text{S}/\text{cm}^2$ , and at one time reaching 345  $\mu\text{S}/\text{cm}$  in the Nabaos observatory (personal communication, A. Petersen, 2002). These values are rather low when compared to other dryland soils (e.g. Richtersveld, South Africa), and might not affect the vegetation in the Nabaos Observatory (personal communication M. Veste, 2002).

The comparative cover assessment, according to the different life-forms in Gellap Ost and Nabaos, also reveals that although Camp B 1 in Gellap Ost is grazed, dry grasses cover the soil extensively even at the end of the dry season and at the beginning of the wet season, before renewed germination rejuvenates the vegetal resources. Also, during humid years, the dry grasses secure year-round protection of the soils at Gellap Ost.

Figure 5a: Species in the low-growing flora in Plot 62 / Gellap Ost Biodiversity Observatory

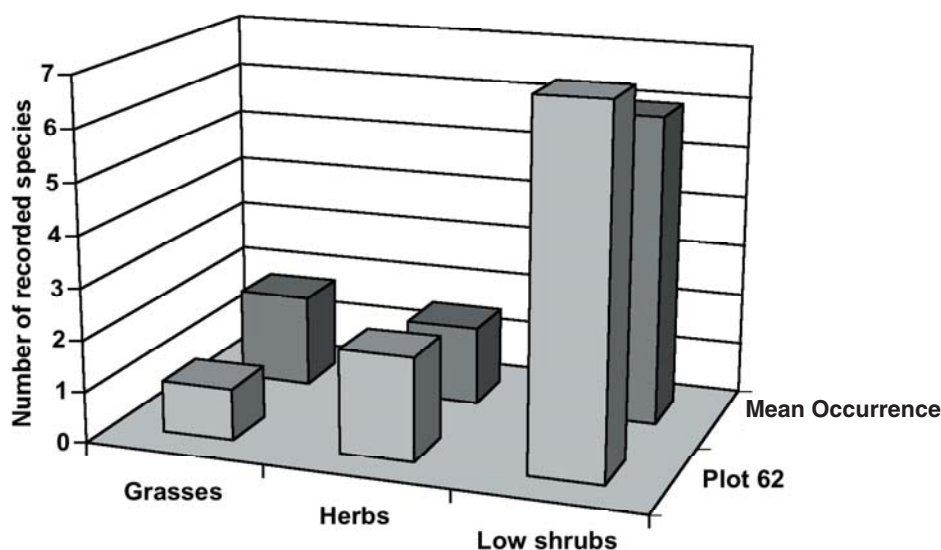


Figure 5b: Species in the low-growing flora in Plot 31 / Nabaos Biodiversity Observatory

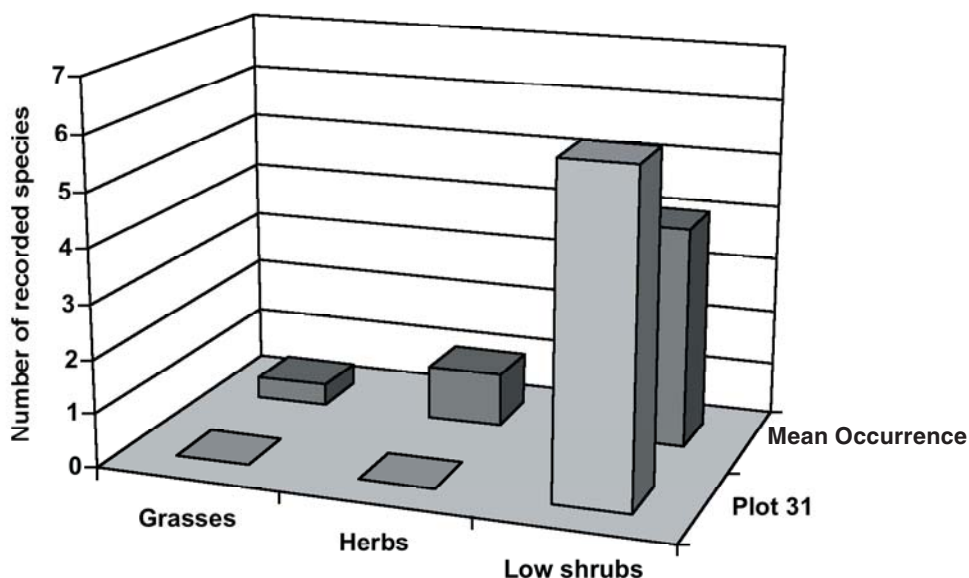
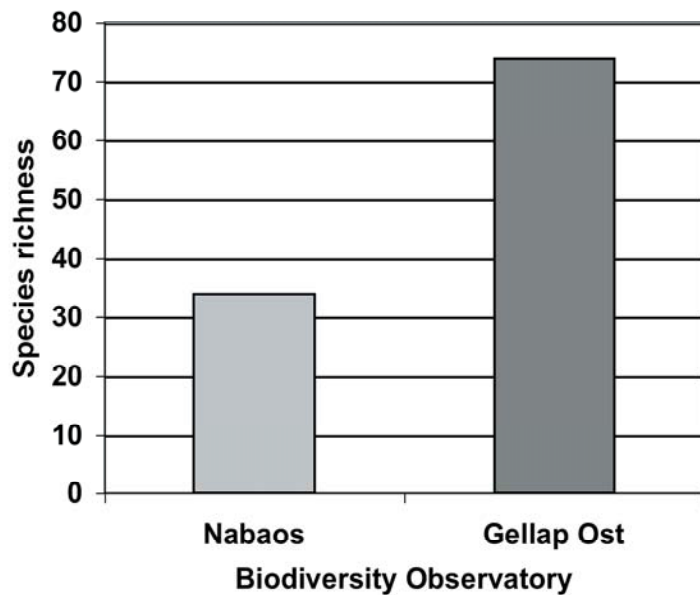


Figure 6: Species richness (by number of species) at the Nabaos and Gellap Ost Biodiversity Observatories



The effects of erosion on the soil of the generally bare and undulating surfaces in the Nabaos observatory has yet to be investigated.

According to Berndt *et al.* (2001), arbuscular mycorrhizal fungi (Glomales) are important symbionts of Poaceae and often improve water interactions and the nutrient status of host plants. Although glomalean spores were detected at Nabaos, and not at Gellap Ost, morphological studies found the Nabaos Poaceae to be non-mycorrhizal. As plant growth and mycorrhization are inter-related, this might be a consequence of overgrazing (personal communication, E. Uhlmann, 2001).

Substantial grazing of woody plants was also observed in the Nabaos biodiversity observatory, evidenced by bark stripped bare and broken twigs. Nevertheless, rejuvenation of *A. mellifera* (Fabaceae) and a wide distribution of *Tetragonia schenckii* (Aizoaceae)—contributing over 20 percent of the woody vegetation cover—were observed. This suggests the initial stage of the phenomenon of bush encroachment. Indigenous shrubs and trees spreading into grasslands is an indicator of the continual removal of the grass layer by heavy grazing and a reduction in the frequency of fires (Hoffman & Ashwell, 2001: 102–105). Bush encroachment, especially in southern Africa, and the spreading of drought-resistant but low-quality grazing grasses in the Sahel (Akhtar-Schuster, 1995), clearly show that even advanced land degradation in the drylands does not inevitably lead to the emergence of desert-like features and therefore desertification. Seedlings of other woody species growing in the area were observed rarely or not at all, suggesting that high exploitation rates in the Nabaos biodiversity observatory may cause a general imbalance in the age structure of woody vegetation.

Compared to the open grazing system in the Nabaos communal areas, the capture-mark-release method used to monitor the diversity and density of small mammals also showed a higher species diversity and density in the regulated farming area of the Gellap Ost Research Station (Zeller *et al.*, 2001: 113). This was seen by A. Hoffmann (personal communication, 2001) as an effect of the denser vegetation cover and greater plant variety, offering protection from predators and the sun as well as providing more microhabitats and additional food.

#### 4. The Effects of Land Degradation

Communal land users are very much dependent on the condition of the vegetation at the observation sites. The people of the Nuwe Fontein settlement near the Nabaos biodiversity observatory are clearly witnessing the deterioration of the surrounding rangelands. The decline in plant resources is not the outcome of rainfall deficiency, but the result of intense exploitation. At the Nabaos biodiversity observatory, the succulent-leaved *Tetragonia schenckii*, which grows extensively in the region, was overwhelmingly seen as the primary grazing source for goats and donkeys. However, one livestock owner commented that this plant alone would be an insufficient food supply, as would be *Rhigozum trichotumum* (Bignoniaceae).

A livestock owner from Nuwe Fontein, when asked whether plants with low palatability are spreading through the observatory area, or whether new species are entering the degraded rangelands of Nabaos, replied, “Overgrazing is not making bad plants replace good plants. It is just that overall plant cover is declining”. Other communal land users at Nuwe Fontein, however, stressed that degradation would not become an issue if their animals were allowed to graze in the area. They claim that with better access to financial services they would enclose their land (restricting access and exploitation of resources in their settlements) and would introduce a rotational grazing system by creating different camps and investing in herds, especially sheep. This clearly indicates that poverty-reduction strategy programmes currently being implemented by development agencies to combat dryland degradation and to promote sustainable development have to be supported by other coherent strategies (e.g. environmental-awareness programmes).

In addition to intense grazing, the woody vegetation at the research site is exposed to continuous and uncontrolled woodcutting. This natural resource not only supplies the daily fuel requirements of the population from Nuwe Fontein and other settlements, but it is also a source of income for the people in the communal Nabaos lands. Although many of those questioned said they only collected dry and dead branches lying on the ground, woodcutters were frequently observed chopping large

branches from living shrubs and trees in the Nabaos observatory site during the field campaign of 2001. The wood is transported by donkey and sold at the nearby city of Keetmanshoop. In Nuwe Fontein, *Acacia mellifera* is seemingly preferred and provides the fuel for daily cooking requirements. However, due to the decline in the number of trees and shrubs in proximity to the settlement, the people of Nuwe Fontein often gather wood within a radius of several kilometres. During the winter months, wood as a heating source is often replaced by gas. But this energy source has a cost and is thus used sparingly. This again highlights the intense pressure placed on the woody vegetation, which is a freely accessible and exploitable natural resource. This begs the question as to whether daily woodcutting, in addition to intense grazing by goats, prevents or even retards bush encroachment in these communal societies. Recording the effects of grazing and woodcutting on the taller shrubs and trees will be another crucial undertaking in the Biota Southern Africa project. A classification index to determine the impacts of grazing is currently being prepared.

## 5. Perspectives

Preliminary research results already indicate the significant impact that uncontrolled grazing has had on biodiversity and its regeneration potential in the Nama-Karoo savannah. Research on flora and fauna diversity indicates that land degradation is severe in the communal Nabaos lands. The dryland habitats of the Gellap Ost Research Station seem relatively intact.

To monitor the effects of land degradation and to estimate the ability of the Nabaos system to regenerate naturally, the following key questions must be asked:

- To what extent will natural regeneration take place?
- How does natural regeneration occur?
- Does irreversible damage already exist?

These questions can only be answered in practice by enclosing a defined area of land (we suggest approximately one hundred and fifty square metres) to halt resource exploitation by humans and domesticated animals for an extended period of time.

Would the "enclosure" project satisfy purely academic interests? We believe that long-term ecological data gathered from the enclosed systems would supply information relevant to developing sustainable land-use systems and cost-effective rehabilitation measures for degraded lands in the areas under investigation.

## 6. Acknowledgments

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Special thanks go to the staff of the Gellap Ost Research Station and to the community of Nuwe Fontein for their friendly support.

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## Footnotes

<sup>1</sup> For further information go to: [www.BIOTA-Africa.org](http://www.BIOTA-Africa.org)

<sup>2</sup> EC 1:2.5 ( $\mu\text{S}/\text{cm}$ )

## Session II: Principles of Dryland Restoration/Rehabilitation in Biosphere Reserves in Asia

# 9

### Dryland Biosphere Reserves In India

*Rama Kant Rai, Director, Ministry of Environment and Forests, New Delhi, India; Member Secretary, Indian National MAB Committee*

#### Introduction:

In 1972, the Indian National Man and the Biosphere Programme (MAB) committee initiated targeted research in different ecosystems in India to improve understanding of their structure and function and to study the impact that anthropogenic pressure has on these various ecosystems. On the basis of the data generated through this research, India's MAB committee identified twenty-six potential sites for biosphere reserves in India, representing the different biogeographic zones of the country. Thirteen of these sites have since been designated as biosphere reserves.

This paper discusses two dryland biosphere-reserve sites in India, from two major biogeographic zones: the hot arid zone of western India and the cold arid zone of northwest India (the trans-Himalayan Region). These arid zones encompass three potential biosphere reserve sites: the Thar Desert in Rajasthan, the Little Rann of Kutch in Gujarat, and the Cold Desert in Himachal Pradesh-Jammu and Kashmir.

Although they have not yet met all the criteria required to be formally given the official status of biosphere reserves, research projects have been sponsored at each of these three sites in order to develop and strengthen the knowledge base that is required to meet conservation objectives, to restore each site's unique biodiversity and its ecological functions, to achieve the sustainable development of local communities, and to develop further research and education activities.

Through multidisciplinary research projects, substantial information has been gleaned on the potential of biodiversity in these areas. Research projects have considered subjects such as: biodiversity-environment relationships, traditional utilization and management of resources, changes in traditional practices, the driving forces leading to change, and the ecological and socio-economic costs and benefits related to these changes. This knowledge provides the scientific basis for the rehabilitation of degraded ecosystems, a key component of biosphere-reserve management.

#### 1. The Hot Arid Zone Biosphere Reserves

##### 1.1 A REGIONAL PERSPECTIVE:

The Indian Desert (better known as the Great Indian Desert) is at the eastern edge of the Sahara-Arabian desert zone that extends from the North African Sahara through Iran, Afghanistan, and Baluchistan and eastwards to the India-Pakistan border. The Indian Desert incorporates both the Thar Desert region — which covers 180,000 square kilometres in the state of Rajasthan — and the Rann of Kutch desert — which covers some 45,000 square kilometres of western Gujarat. In total, the Indian Desert extends over 285,680 square kilometres, stretching across the states of Rajasthan, Gujarat, Punjab and Haryana: between 22°30'N and 32°05'N and 68°05'E and 75°45'E.

The Thar is the world's most populous desert. However, due to biotic pressure, the whole desert ecosystem of the Thar is in danger of deteriorating into a vast wasteland. Certain germplasms endemic to the desert are in the process of extinction. The regional climate is characterized by temperature extremes from 0°C to 50°C with scant and erratic rainfall. The soil is typically light in texture and loams form the bulk of the soil in this region.

Due to its evolutionary history and geographical location, the Thar Desert contains a spectacular biological diversity. The vegetation is largely of the thorn forest type and much of the area is cultivated. The grasses, shrubs and trees of the area (nearly seven hundred species) are well adapted to the environment. Three hundred bird species have been recorded in the area. Only recently, the Asiatic lion and the Asiatic wolf, once found in the Thar Desert, have become extinct from the area. The region has been subjected to feudal order for centuries and this has been coupled with a sizeable increase in the human population.

## 1.2 THE PROPOSED THAR DESERT BIOSPHERE RESERVE

The Thar Desert is of outstanding beauty. Its unique life forms, which have become adapted to the harsh dryland conditions, constitute an invaluable stock of rare germplasm. This fragile ecosystem is likely to disappear forever if the current pace of biotic pressure continues.

It is for this reason that a significant section has been proposed to be protected under the status of the Thar Desert Biosphere Reserve, serving as a benchmark model to be kept in pristine condition and restored to its original status. The area is situated between 25°47'N and 26°46'N and between 70°15'E and 70°45'E, extending over thirty-one hundred square kilometers and including parts of both the Jaisalmer and Barmer districts of Rajasthan. This desert region experiences temperatures ranging between 1°C and 50°C.

The area was nominated as a sanctuary under India's Wildlife (Protection) Act 1972. As well as its incomparable natural landscape and landforms and unique vegetation, traditional land use and animal husbandry are still practiced throughout the region.

The water table has a depth of thirty-five to one hundred metres and is generally brackish, and the proposed biosphere reserve features semi-shrub desert vegetation. A rich insect fauna plays a remarkable role as micro-consumer. The bird fauna in the region exhibits a conspicuously Ethiopian influence. The great Indian bustard (*Ardeotis nigriceps*) is found in relatively large numbers. The region is also a haven for certain migratory birds, including the rosy pastor (*Sturnus roseus*) and the spotted starline (*Sturnus vulgaris*), which arrive from Europe soon after the rains. A total of three hundred species of birds have been recorded in the region. Over sixty species of mammals including Chinkara (*Gazella dorcas*), the desert cat (*Felis libyca*) and the wolf (*Canis lupus*) are fairly common in the area.

The reserve area includes thirty-one villages. Ninety percent of the population depends largely on livestock rearing, with little or no agricultural activity. Livestock migration is determined by water availability in the rangelands. Following the rainy season, the animals migrate beyond the reserve area. The area is a representative unit of the desert biome. The population of the area in 1901 was 3.56 million, which had increased to 20 million by 2001. The current population density of approximately eighty-five inhabitants per square kilometre is the highest in the world's deserts.

Archaeologists and historians share the view that the Thar is approximately ten thousand years old, however scientists of the Central Arid Zone Research Institute in Jodhpur estimate that the Indian desert is considerably older, arguing that its endemic biodiversity could not have evolved in a mere five to ten thousand years.

## Management

Many of the problems faced in the region have resulted from over-grazing, wildlife poaching, and the collection of fuel wood. It is thus necessary to restore the degraded habitat and to maintain the fragile environment in as natural a state as possible. Rotational grazing and a restriction on fuel-wood collection need to be imposed. Alternative income-generating options need to be presented.

The management programme will focus on the rotational grazing of livestock in the rangelands (approximately two thousand kilometres). The rangelands must be fenced before any management programme is launched. Re-seeding high-yield perennial grasses is the best way to increase forage, and simultaneously removes unwanted bushes. Tree-planting programs, veterinary care, the establishment of alternative sources of energy, and public health projects can provide employment.

## Ecosystem Differentiation and Management in Traditional Village Landscapes

The landscape in this region is relatively less heterogeneous than that of the cold desert. A typical village landscape can be differentiated into five land-use and ecosystem types: domestic, agriculture, private grazing lands, common grazing land, and sacred groves.

The indigenous communities of *Bishnois* worship the multipurpose indigenous tree *Prosopis cineraria*. This is a culture that exhibits an appreciation of biodiversity; felling green trees, castrating bullocks, or selling livestock to butchers are strictly forbidden.

In the hot desert, where outside influences and population pressure seem to be more aggravated than in the cold desert region, it is thought that the establishment of sacred groves was a socio-religious response to a recognition of the need to conserve biodiversity and its ecosystem services. Sacred groves invariably cover areas where biodiversity is relatively intact. The similarity in the floristic composition of sacred groves and of privately owned grazing land, and the minor differences in species richness, suggest that systematic low-intensity grazing is not detrimental to species diversity. However, uncontrolled grazing in common grazing lands causes depletion of biodiversity.

Socio-cultural norms as the mainstay of conservation mechanisms are fast changing. This is largely due to property rights imposed by the state, a cultural change from a subsistence to a market economy, and the establishment of development programmes that neglect the importance of the inter-relationships between crop, livestock, and the natural ecosystem in traditional landscape management. In addition, the politicization of indigenous attitudes has proven to be more detrimental to biodiversity conservation than human or livestock population growth (Ramakrishnan *et al.*, 1998).

## Rehabilitation of Degraded Lands

A high degree of salinity-alkalinity in soil as well as groundwater, the depletion of soil organic matter and available nutrients, and poor *in situ* natural regeneration are major limitations to the recovery of ecological and socio-economic functions of degraded terrestrial ecosystems in the hot desert region. The ecological stresses are so acute that ecosystem recovery through the process of natural secondary succession, even if provided full protection, is likely to be very slow. Amelioration of soil stresses and plantation seems to be necessary for accelerated recovery.

The tree species *Prosopis cineraria*, *Tamarix articulata*, *Parkinsonia aculeata*, *Salvadora*, *Casuarina equisetifolia*, *Leucaena leucocephala*, *Acacia nilotica* and *Albizia lebbek* have been found to be salt tolerant and suitable for plantation in the degraded lands in arid regions. These species are not only ecologically suitable, but also socio-culturally acceptable to local people. Of the five planting techniques tested — the pit method, the ridge-trench method, the auger-hole method, the pit-auger hole method, and the pit-auger hole and furrow method — the pit auger hole and furrow method has been found to be most effective. The use of a basal dose of gypsum, pyrite and organic manure has been found to improve survival and growth rates (Tomar, 1997). These conclusions, drawn from experimental research, need to be transposed into the field and monitored for their effectiveness under varied ecological, socio-economic and cultural scenarios. It is anticipated that some level of amelioration of ecological stresses as a result of planting and soil management will be followed by a natural course of regeneration from seed rains and the dispersal of propagules by animals from the dense and less disturbed vegetation in the sacred groves.

## 2. A High-Altitude Cold Desert Biosphere Reserve

### 2.1 REGIONAL PERSPECTIVE

The trans-Himalayan region in the rain shadow zone of the main Himalaya is commonly considered a high-altitude cold desert. Only eighty-five thousand square kilometres of this zone of 2.6 million square kilometres is inside the Indian territory, with the rest in the Tibetan autonomous region of China.

The bulk of the trans-Himalayan region in India lies in the Ladakh region of Jammu and Kashmir State, and the Lahul and Spiti district of Himachal Pradesh. The region receives very little precipitation and experiences extremes of cold, which accounts for its low productivity and sparse vegetation, though wild animals have adapted to the local conditions. However, drastic changes occurring as a result of ever-increasing human pressure and

ill-planned development activities have posed a real threat to the very existence of the region's delicate life-support systems. An area of approximately forty-two hundred square kilometres in Himachal Pradesh, Jammu and Kashmir has been proposed for designation as a biosphere reserve.

### 2.2 ECOSYSTEM DIFFERENTIATION AND MANAGEMENT IN TRADITIONAL VILLAGE LANDSCAPES:

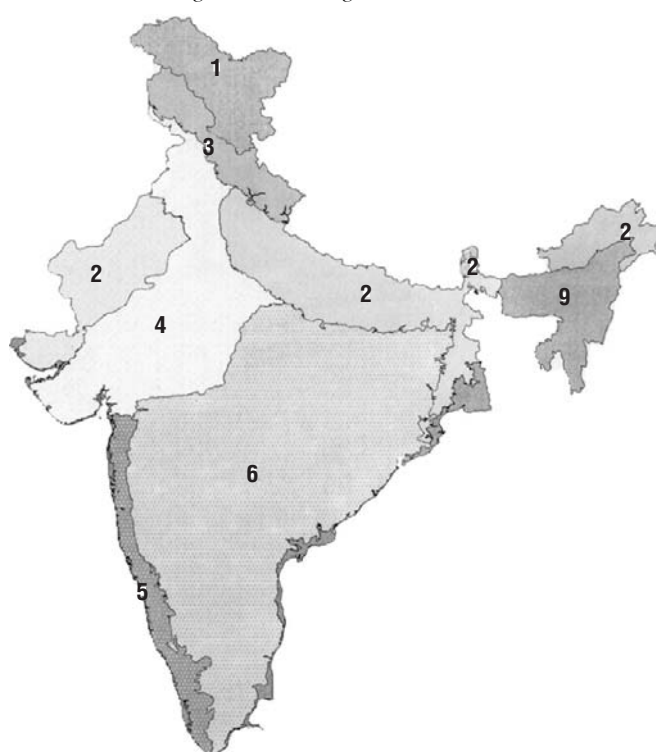
Two contrasting types of village landscapes can be distinguished in the region:

- Villages characterized by a relatively warmer climate (lower altitudes), greater accessibility, large-scale transition of traditional crops for cash crops in private farms, and a high ratio of private farms to common grazing land.
- Villages characterized by relatively cooler climates (higher altitudes), poor accessibility, an absence of or little transition of traditional crops for cash crops and a low number of private farms.

Land managed by settled farmers is differentiated into three ecosystem types: (a) agro-ecosystems, (b) meadows subjected to grazing, and (c) meadows in which plant species are selectively harvested to provide winter feed for livestock as well as other needs.

Land subjected to disturbance from intermittent grazing is differentiated into: (a) land in which short-term grazing of all types of livestock is practised in early summer (May and June), (b) land in which short-term grazing of all

Figure 1: Arid Regions in India



1. High Altitude Cold Desert — Trans Himalaya  
3. Hot Arid Zone — Desert

types of livestock is practised during the summer-winter transition months (October and November), (c) land in which long-term grazing of horses is practised from June to September, and (d) land in which grazing by all types of livestock excluding horses is practised long-term.

Rapid changes in agricultural land use, with significant implications for the conservation of biodiversity and ecosystem services, are progressing. These changes are driven by the local people's increasing drive towards a cash-crop economy, the comparative ecological advantages of sweet-pea cultivation, and the penetration of market forces as a result of this traditionally highly inaccessible area becoming more open. The change incurred by the replacement of traditional staple food crops such as barley and black pea with crops yielding greater amounts of fodder has increased grazing pressure on the meadows.

Intensive grazing has promoted the dominance of *Caragana versicolor* across the elevation gradient sampled. Low-intensity grazing combined with cutting has promoted the dominance of *Cicer microphyllum* up to an altitude of forty-four hundred metres, and *Cousinia thomsonii* up to an elevation of forty-eight hundred metres on relatively dry slopes.

Wildlife causes significant damage to the livestock but not to traditional crops. Livestock being killed by wolves is more frequent in high-altitude villages, despite the local tradition of capturing infant wolves as a means of keeping the wolf population low (this local traditional belief has yet to be corroborated scientifically). Livestock being killed by leopards is more common in villages at lower altitudes, where it is culturally prohibited to kill leopards.

Huge quantities of dung are used for energy purposes, and significant human time and energy is spent on collecting the air-dried dung from meadows and fallowed crop fields. Ash is stored and added to crop fields during ploughing. Alternatives to these traditional practices need to be developed.

Soil is dug out in an unsystematic manner and spread onto snow to accelerate melting and hasten sowing. Implications of this traditional practice on conservation need to be further investigated.

## 2.3 REHABILITATION OF DEGRADED LANDS IN COLD DESERTS

The extent and intensity of degradation in the cold desert region is not as conspicuous as in the hot desert region, because of lower population pressure and the limited influence of past market forces. The ongoing changes in private farmlands are such that pressure on natural ecosystems will increase in coming years. Traditionally grown *Pisum arvense* (black pea) and barley (Himalayan winlense) are fast being replaced by cash crops such as green pea (*Pisum Sativum*). The intensification of agricultural land use seems to pose a more serious

threat to conservation than the *extension* of agricultural land use. Increasing fodder productivity should be a key consideration in any land-rehabilitation programme.

Species harvested in large quantities from the wild include *Cicer microphyllum*, *Cousinia thomsonii*, *Polygonum tortuosum*, *Artemesia salsaloides*, *Seseli trilobum*, *Thermopsis inflata*, *Caragana versicolor*, *Krascheninnikovia ceratoides*, *Astragalus zanskarensis* and *Sedum quadrifidum*, which are used as fodder, mulch, and fuel. These species, crucial for local livelihood, seem to provide the potential necessary for redeveloping farming systems and rehabilitating degraded lands.

Strict socio-cultural controls in these areas have traditionally played an important part in balancing resource use and land recovery. For example, grazing and harvesting for fodder, mulch, and wood are restricted to days fixed by the village council, and defaulters are penalized. Even the timing of sowing, ploughing, weeding, harvesting, and irrigation are strictly prescribed in high-altitude villages. These socio-cultural controls favoring sustainable resource use were found to be stronger in remote high-altitude villages than in more easily accessible roadside valley villages. Institutional arrangements for land rehabilitation in any biosphere management programme need to be built on indigenous traditions and culture.

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# 10 Rehabilitation of the Aral Sea Environment, Kazakhstan

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## Abstract

The Aral Sea environmental crisis not only affects the dry sea floor adjacent to the Aral Sea (the new Aralkum Desert covering forty-two thousand square kilometres), but also vast stretches of the sea's two main tributaries, the Amudarya and Syrdarya rivers.

The dry sea floor amplifies the environmental disaster, as from fifteen to fifty million tonnes of salt (mainly NaCl but also alkaline salts, herbicide residues and other pollutants) is swept by sandstorms across villages and irrigated lands every year. The resulting degradation and desertification processes threaten the entire population of the area and endangers their livelihoods. Current knowledge and information on the status of land degradation and activities in the Aral Sea region affected by the crisis has improved but is still incomplete. Regular monitoring of the status of the various ecosystems and land-use practices is necessary and important because of its dynamic yet unstable ecological balance. Rehabilitation of the main parts of the degraded region requires: (1) restoration of lost ecosystems (2) phytomelioration of open salt flats and sand dunes (3) establishment of a network of regional protected areas (4) establishment of a sustainable land-use system for grazing and, where possible, small local irrigated agricultural systems incorporating trees and garden crops. The projects should take into account the harsh ecological and climatic conditions of the area: namely high salinity levels, drought and high temperatures during the summer months, and severe winter frosts.

## Introduction

The Aral Sea crisis is unique in that there are no analogous features in terms of size or intensity found anywhere else in the world (Agachanzan 1988, Walter & Breckle 1994, Letolle & Mainguet 1996, Giese 1997, Klötzli 1997, Breckle *et al.* 1998). The last millennia has witnessed several regression and transgression periods in the Aral Sea relating to changes in regional and global climatic

systems. However, the rapid regression observed since the 1960s (see Table 1) has been caused by the major irrigation projects undertaken during the Soviet era in the catchment areas of the Amudarya and Syrdarya rivers flowing through Uzbekistan, Turkmenistan, Kirghizia and Kazakhstan. The waterflow from the rivers to the Aral Sea fell from an annual average of sixty or seventy cubic kilometres before 1960 to a low of four to ten cubic kilometers annually in the 1980s. But since 1990, the average water input into the Aral Sea has increased again to almost fourteen cubic kilometres annually. This very positive development signifies a deceleration of further drying out of the Aral Sea.

In 1960, the Aral Sea was the world's fourth-largest lake. The area of the dry sea floor is now greater than the Netherlands, and the area of the remaining Aral Sea is less than one-third its original size. The dry sea floor on the east coast flats stretches over approximately one hundred kilometers (Figure 1).

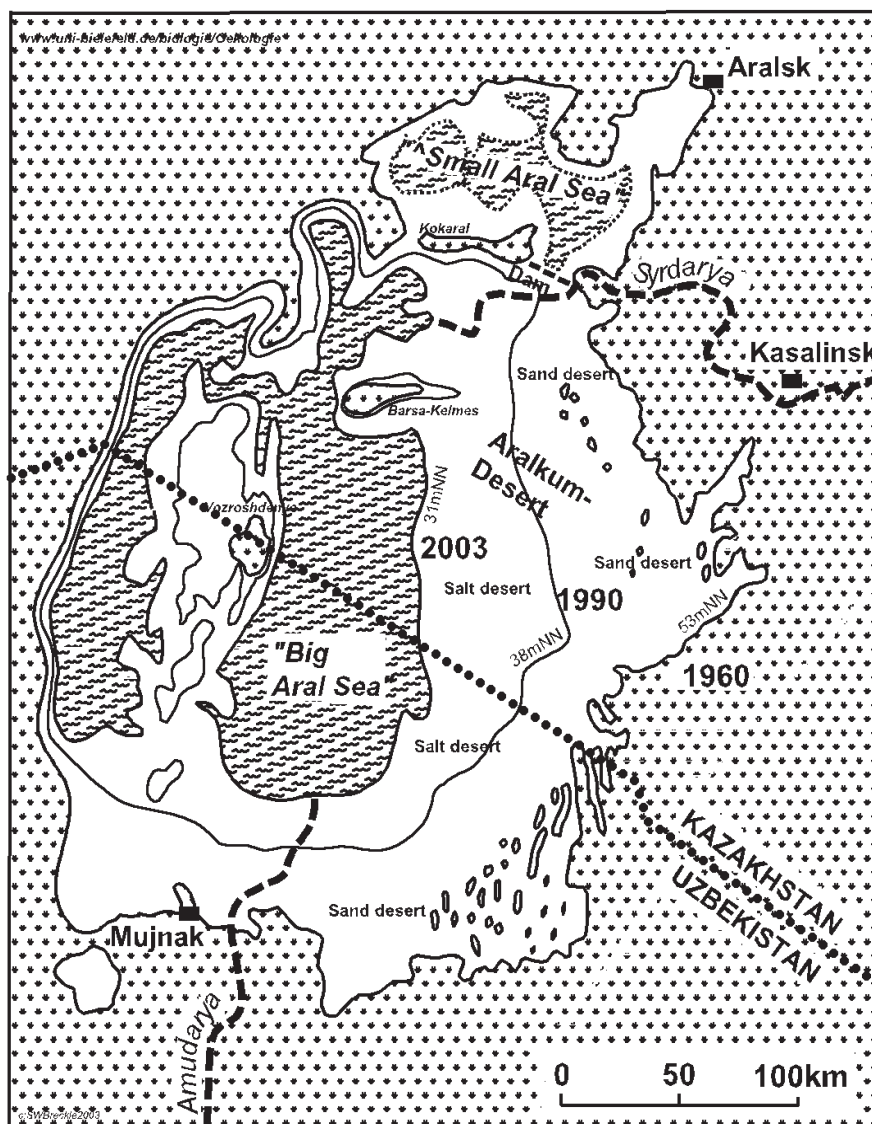
The volume of water has decreased even more dramatically. From the original water body, only 15–18 percent remains. The northern part is now hydrologically independent and has become the Small Aral Sea, while the larger southern part (the Great Aral Sea) is separated into a shallow basin to the east and a deeper basin to the west. These basins are partitioned by the Vozroshdenie Peninsula, on which remnants of Soviet biological and chemical weapons pose a further threat to the wider environment. The Small Aral Sea was originally separated by an artificial dam, but this was ruptured by a violent storm in April 1999. The Syr Darja is now discharging its surplus water into the Great Aral Sea. In addition, water loss through evaporation and the drop in water input from the two feeder rivers has led to a dramatic increase in the salt concentration of the seawater, from being slightly brackish before 1960 to hyper-saline (in the Great Aral Sea) today. This has caused the loss of the halieutic fauna and the resultant demise of the once prosperous fishing industry.

Table 1: Dynamics of the water surface of the Aral Sea and the dry sea floor (Breckle et al. 2001).  
Data from the Small and Great Aral Seas

| Year | Water Level (m NN) | Water Surface (km <sup>2</sup> ) | Dry Sea Floor Area (km <sup>2</sup> ) | Sea Salinity(% NaCl) |
|------|--------------------|----------------------------------|---------------------------------------|----------------------|
| 1960 | 53.4               | 68 000                           | 0                                     | 0.9                  |
| 1970 | 51.5               | 61 000                           | 7 000                                 | 1.2                  |
| 1980 | 46.0               | 52 000                           | 16 000                                | 1.7                  |
| 1990 | 38.5               | 38 800                           | 29 200                                | 3.4                  |
| 1999 | 32/36 *            | 27 700                           | 40 300                                | 4.2/ 3.2 *           |
| 2001 | 31/37 *            | 23 000                           | 45 000                                | 5.2/ 2.5 *           |

\* approximate data

Figure 1: The disappearance of the Aral Sea from 1960–2003 and the location of the new Aralkum Desert



At present, the Aral Sea basin and the wider region host a very complicated system of canals, reservoirs, both irrigated and abandoned fields, and hydro-technical constructions. This includes 7.9 million hectares of irrigated lands, mostly abandoned and therefore salinized, a 323,200-kilometre irrigation network, and 161,800 kilometres of drains and collector basins (Orlovsky *et al.* 2001). Despite such wide-scale water construction, the irrigation techniques commonly used are the same or worse than during the Middle Ages — mainly border, basin and furrow irrigation. Under such a land-use system, a large quantity of water is non-exploitable or lost, while further quantities are drained into large depressions or transported to other dispersed areas. Improper irrigation leads to secondary salinization, waterlogging and desertification. The diversion of drainage water to the rivers results in the deterioration of water quality, while diverting this drainage to marginal desert areas results in the waterlogging of pastures and the environmental degradation of the total area.

The sequence of natural primary succession on the dry sea floor (Breckle 2002b) varies depending on the substrate. Vast stretches are made up of sandy soils, which have mainly developed during the first phase of the desiccation process (1960–1980), when salinity rates were still relatively low and sand-dune systems were developed by Aeolic activity. Over the last two decades salinity has increased to seawater concentration, and the desiccated surfaces now exhibit strongly saline solonchak soils that are high in clay content.

Primary succession on sandy soils (see Figure 2) is characterized by rather high biodiversity. Over a period of several years, succession leads to typically psammophytic tufts of vegetation, which are only sufficiently dense locally, while vast areas remain open mobile sands. Primary succession on saline clay soils (Figure 3) is characterized by a relatively slow advancement of plants. The desert under succession is typically bare of plants, making up the majority of the area. However, the plants are dynamically represented, as these open areas contain halophytic vegetation during the first years of the succession process, consisting of the annual *Salicornia europaea* (wet soils) and *Atriplex fominii*, *Suaeda* and other annual halophytes in successive years, depending on weather and water conditions (moist or dry soils). Invasion of the lower shrub, *Halocnemum strobilaceum*, the most salt-resistant plant in the area, and found in other salt deserts of Central Asia (Breckle 2002a, 2002c) takes place in some areas, while elsewhere remains an open and bare salt desert. Vital remnants of the Tugai forest can be found along rivers and water channels of the delta areas.

The ecological characteristics observed during the succession process have been studied by Wucherer and Breckle (2001). The studies reveal how one of the

final stages in the succession sequences could become dominated by *Haloxylon aphyllum* (the Saxaul), which can grow to a height of six metres. Such vegetation cover could effectively halt the action of the wind on the bare surfaces. It should be noted that destruction of the vegetation was first begun in the nineteenth century, when woodlands made up of *Haloxylon aphyllum* and *Tamarix* species were cut down to provide the Aral steamship flotilla with firewood (Dimeyeva 2001). Clearing became more intense after the construction of the railway at the beginning of the twentieth century, and as a result, the *Haloxylon* woodlands on the islands and the coast of the former Aral Sea were almost totally cleared. This was one of the main threats to biodiversity in the region for many decades. Other human activities impacting and contributing to the desertification process in the area include overgrazing and techno-genic factors resulting from the chemical and aeronautical industry.

## 1. Rehabilitating the Environment.

Many disputes still continue as to future directions in the planning and development of the area. Restoration of the Aral Sea to its 1960 dimensions would necessitate the cessation of most agricultural activities along the main two rivers. With the dramatic population increase and the growing need for food production through intensified agriculture, this seems highly unrealistic. Yet more should be done to increase water efficiency and drainage to prevent further salinization.

Another possible solution discussed involves deviating water from the large Siberian rivers (the Sibaral Project). This would be a major project involving considerable ecological risk for the northern Siberian forest, the mire, and the tundra areas, as well as being excessively costly. The deviation of water from the Indus to the southeast is even more fanciful. Thus, plans to improve the water table in the region should take into account the *lower* level of water in the Great Aral Sea as well as the level of controlled water from the dam in the Small Aral Sea. Essentially, it is important to note that in the future the water level of the Great Aral Sea may vary from decade to decade.

Recommended objectives for the near future:

1. Minimize salt and sandstorm effects.
2. Conserve the high biodiversity of the specific vegetation on the dry sea floor and along the old Aral Sea coast.
3. Improve the present situation of the desiccated sea floor.

An integral part of the programme is to improve living conditions in the villages and towns adjacent to the Aral Sea. Projects to improve the socio-economic situation should include improving health systems, guaranteeing

Figure 2: Succession on sandy soils during the dessication of the Aral Sea floor and by increasing Aeolian activity

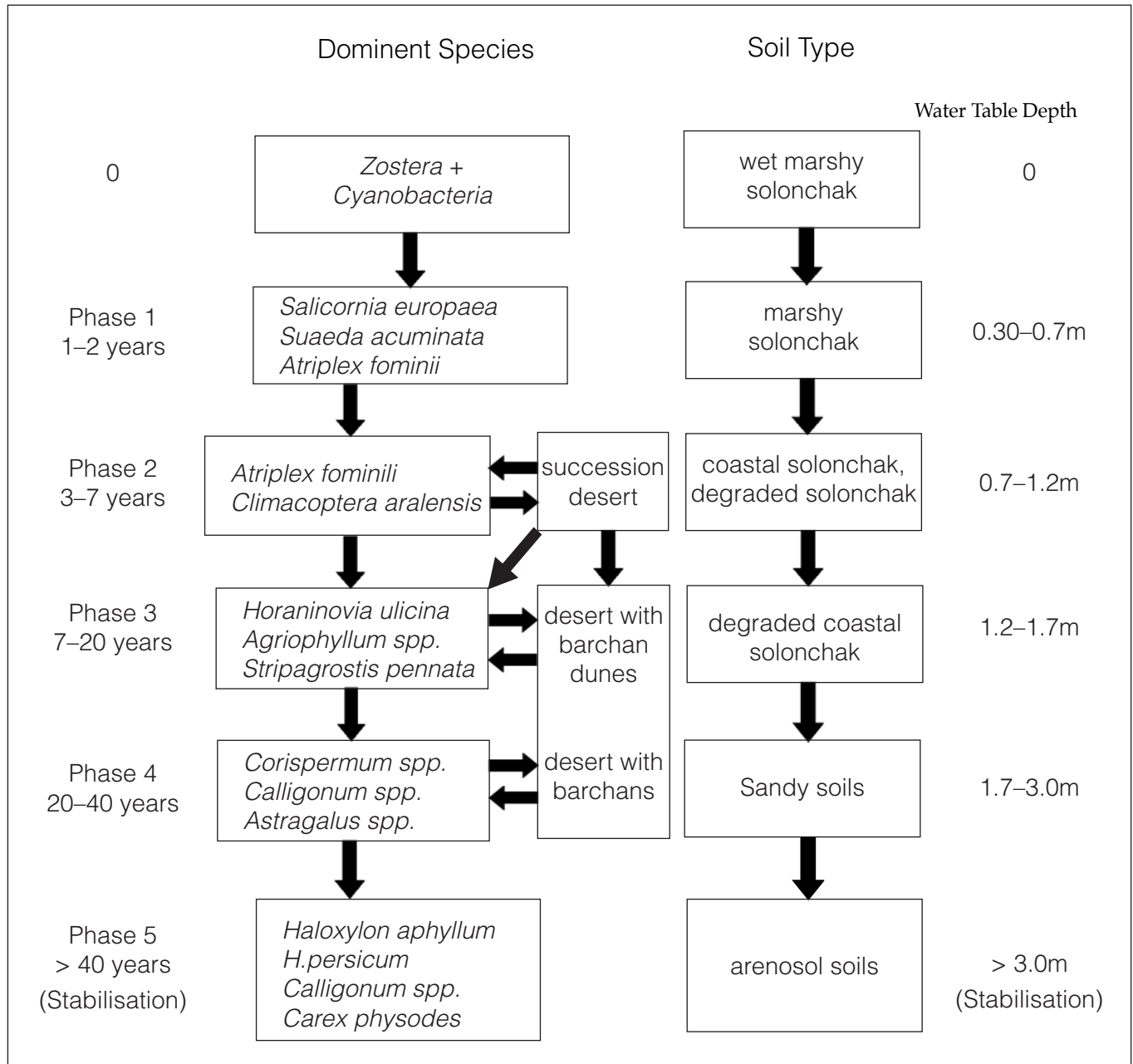
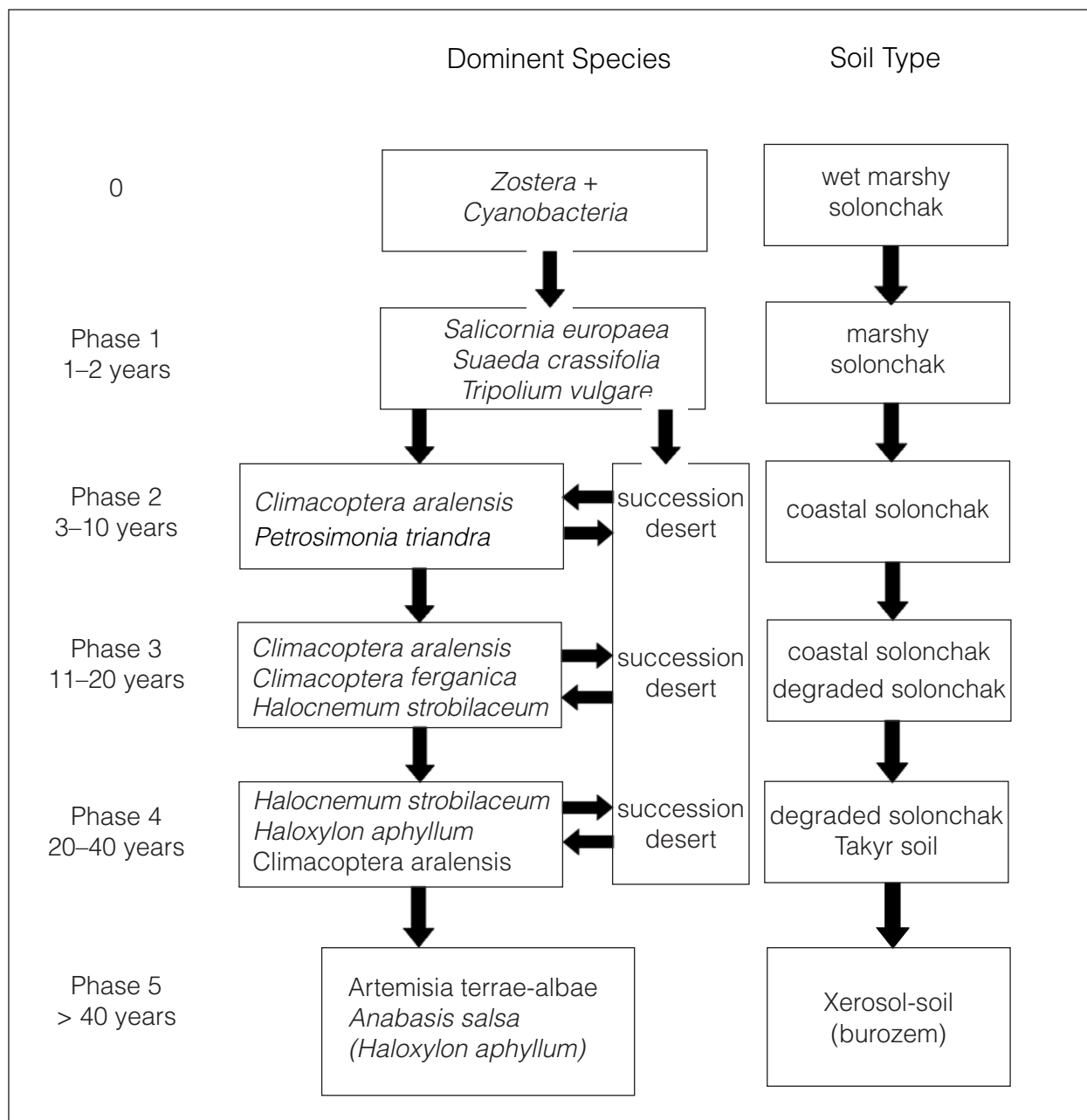


Figure 3: Succession on loamy/clay soils during the dessication of the Aral Sea floor.



access to clean water and energy, and maintaining the food supply and infrastructure.

Recommended actions to achieve these aims:

- a) Establish extensive planting systems of seedlings on the sandy surfaces and on the *solonchak* (Russian for "salt marsh") by applying new techniques for snow and water run-off collection. Apply scientific knowledge to succession processes and sequences.
- b) Establish biological research stations and research projects to observe and monitor desertification processes in the major landscape units.
- c) Build capacity through working with local people, sharing responsibility for projects, providing ecological training and education, and increasing public awareness of the problems of desertification.
- d) Work together with Uzbek and Kazak projects (with governments, district officials etc.) in areas of rehabilitation and conservation, and collaborate more effectively with development and international aid agencies.
- e) Establish a nature-reserve system, in relation to landscape planning and subsequent evaluation by satellite imagery.
- f) Protect the remaining isolated areas of Tugai forest and promote the expansion and dispersal of this forest.
- g) Promote the national park as a potential site for ecotourism (hot springs, cultural monuments, safari trips etc.).
- h) Establish a management system for sustainable grazing in limited areas.
- i) Establish a management system for hunting in limited areas as a means of wildlife protection.
- j) Establish small development centres for irrigated lands along water channels surrounded by trees and garden plants, creating intensive agricultural oasis systems, surrounded by forest shelter belts.
- k) Rehabilitate salinized agricultural land along the Syrdarya and Amudarya rivers by concentrating on small units and intensified agriculture using modern technology.
- l) Minimize effects from the old chemical and biological weapons experimental area in Vozroshdenie.

These action can only be accomplished through co-operation with local authorities. In any case, few alternatives remain since an improvement of the present disastrous situation must be attained.

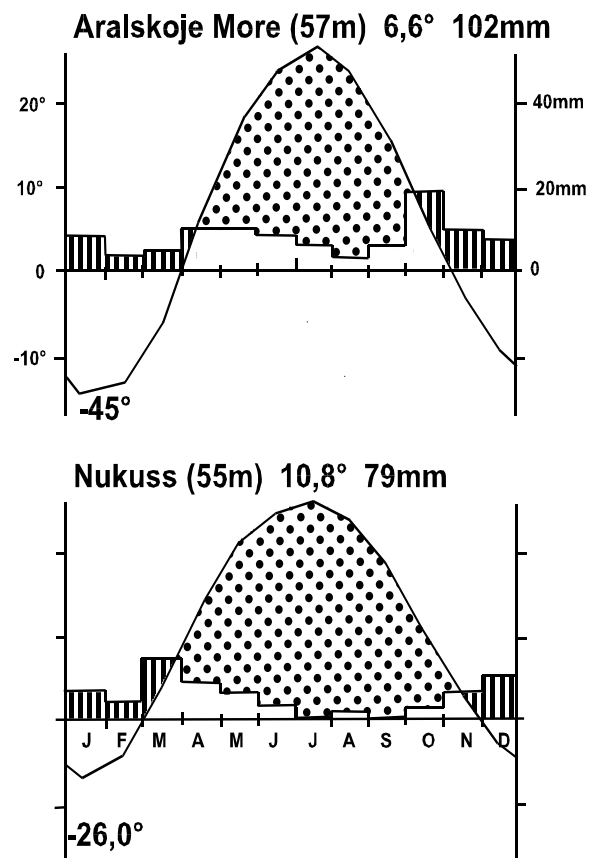
Due to the multiplicity of potential actions, it is not possible to discuss all necessary future efforts and projects in detail. However, some remarks and data on phytomelioration will be given relating to our research results and future research activities.

## 2. Phytomelioration

The desiccated Aral Sea area is an inhospitable substrate for the colonization of plants. Without an additional water supply, establishing a dense vegetation cover is next to impossible. Thus, only small local centres of irrigated land can be planned and used for intensive agriculture in the development of small new oasis systems. Annual precipitation amounts to approximately one hundred millimetres, and consists mainly of snow during the long cold winter periods. Annual temperatures are typically high continental, exhibiting very hot spells in summer (up to 45°C), and very severe frosts during the winter (falling to below -35°C, with an absolute minimum of -45°C in Aralsk) (see Figure 4). This suggests that only a small number of plant species are suitable for phytomelioration projects. Dimeyeva (2001) suggests two methods for biodiversity conservation: the restoration of lost ecosystems and the establishment of a network of regionally protected areas.

Phytomelioration and afforestation have been carried out periodically along the Aral Sea coast. Restoration of natural ecosystems could be achieved through artificial phytocenoses. The remaining natural vegetation units

Figure 4: Climatic diagram of Aralsk (northern Aral Sea) and Nukuss (southern Aral Sea)



along parts of the sea coast can serve as models for the creation of man-made ecosystems, as well as being important sources of diaspores. Reintroduction in suitable habitats of the disappearing wild vegetation could accelerate the natural succession process and help create a seed bank, furthering the natural dissemination of the vegetation.

One four-hectare plot and a number of one-hundred-square-metre test plots were established southwest of Aralsk to revive the *Haloxylon* and *Tamarix* communities (Dimeyeva 2001). Saplings of *Haloxylon aphyllum*, *Tamarix laxa* and *T. hispida* were planted and seeds of *Haloxylon aphyllum*, *Ceratoides latens*, *Salsola orientalis* and some annuals were sown in the test areas. Early results of the growth and establishment of the species are very promising, clearly demonstrating that such artificial plantings are necessary and prove to be successful. It should be noted that the heterogeneity of the soil found in the test areas reveals uneven growth responses, and that another important factor remains the variability of winter and spring rains. It has been shown that good results from sapling planting and seeding projects require at least one wet winter season. This was also demonstrated by Meirman *et al.* (2001) with experiments on solonchak soils. Most replanting projects were carried out in sandy areas.

For several years now, an “afforestation of the desert” project has been taking place on the Uzbek southwestern Aral Sea floor, and as recently as last year this became a development project financed by Germany. With the help of heavy machinery, a vast area covering thousands of hectares of sandy substrate was planted with *Haloxylon aphyllum* and a tree nursery was created. Results so far are very promising as salinity is low and the sandy soils protect rainwater against evaporation, so that it can be almost totally utilized by the plants. Over time, an equilibrium between plant density and height will be established, depending on the amount of water used through transpiration and evaporation (this is negligible for sand). However, natural sand-dune systems in the area demonstrate how open vegetation cover, in equilibrium with the autochthonous water supply, is sufficiently dense to minimize sand storms, sand movement, and thus dune development. Eventually, old *Haloxylon* stems could be sustainably used for firewood or other purposes.

The vast saline areas that became desiccated after 1980 pose many problems for afforestation. These problems arose due to the high salinity of the solonchak soil as well as from the very high percentage of clay contained in the soil, which alters the physical and chemical structure of the soil preventing the penetration of roots and thus the establishment of most plants. Again, it is necessary to look towards natural succession as a model, taking into consideration the geo-morphological features of the area, in order to evaluate the best environ-

mental conditions for plant colonization on such harsh substrates. Field experiments carried out on a crust solonchak (0–2 cm crust: 24.5 percent salt per dry matter, 10.4 percent Cl; 5.15 percent  $\text{SO}_4^{2-}$ ; 7.85 percent  $\text{Na}^+ + \text{K}^+$ ) situated to the southwest of the former Kaskakulan island (Meirman *et al.* 2001) demonstrate that seeding experiments can be successful, despite the low germination percentages (see Table 2) and slow growth observed throughout the dry year. The experiment also revealed the suitability of the annual plant *Chenopodiaceae*, however perennials were shown to require special treatment.

For the year 1997, no germination at all was observed at the site among the following species: *Limonium gmelinii*, *Karelinia caspica*, *Pseudosophora alopecuroides*, *Halostachys caspica* (Ch), *Haloxylon aphyllum* (Ch), *Suaeda microphylla* (Ch), *Salsola australis* (Ch) and *Halocnemum strobilaceum* (Ch).

These experiments revealed that the harsh environmental conditions enable only a few species to grow and establish (only 23.5 percent of species). In another similar seeding experiment, carried out by Meirman (2001), it was observed, however, that some perennial species had successfully germinated, particularly *Haloxylon aphyllum* (see Table 3).

One very important phenomenon was observed. It was found that many seedlings germinated and grew during the spring months due to surface desalinization following snow melt. The seedlings began to die off in June because of surface salinization, due to the high rate of evaporation of the fine particle soil, and by the unearthing of roots by strong winds. In the second field experiment, ecological conditions were more favorable. The slight sand cover on the solonchak surface allowed for germination, as well as a 67 percent development of seedlings at the vegetative stage. Most plants were healthy and the annuals produced seeds.

We can draw the following conclusions from these results:

- 1) Even small proportions of sand or a shallow sand cover on the solonchak soil provides improved conditions for the implementation of phytomelioration measures.
- 2) The aridity of the first vegetation period plays a major role in the establishment and thus the survival rate of seedlings and saplings.
- 3) Local flora species are generally more effective for phyto-reclamation. Species derived from spontaneous natural succession sequences are best suited.
- 4) The development of soils and formation processes on the dry Aral Sea floor is still continuing; a final balance between herbaceous cover and shrubs has not yet been reached (no climax situation has been observed).

Table 2: Phytomelioration was performed on crusty clay soils (solonchak) near Kaskakulan, eighteen kilometres west of the former coastline. It was impossible to evaluate the germination percentage, but the number of plant individuals was taken into account. Seeding was carried out in Nov. 1997. Ch = Chenopodiaceae

| Plant                                | Quantity of Plants in Recorded Areas |          |          | Plant Height (cm) |          |
|--------------------------------------|--------------------------------------|----------|----------|-------------------|----------|
|                                      | 22/04/98                             | 01/06/98 | 23/08/98 | 01/06/98          | 23/08/98 |
| <i>Suaeda acuminata</i> (Ch)         | 77                                   | 62       | 51       | 1.0               | 5.0      |
| <i>Halogeton glomeratus</i> (Ch)     | 27                                   | 27       | 27       | 4.0               | 9.0      |
| <i>Climacoptera aralensis</i> (Ch)   | 35                                   | 32       | 11       | 1.0               | 2.0      |
| <i>Atriplex fominii</i> (Ch)         | 43                                   | 30       | 10       | 1.0               | 8.0      |
| <i>Atriplex tatarica</i> (Ch)        | 125                                  | 89       | 0        | 1.2               | -        |
| <i>Petrosimonia brachchiata</i> (Ch) | 39                                   | 37       | 0        | 1.5               | -        |
| <i>Salsola nitraria</i> (Ch)         | 23                                   | 23       | 0        | 0.5               | -        |
| <i>Climacoptera lanata</i> (Ch)      | 17                                   | 16       | 0        | 1.3               | -        |
| <i>Kalidium caspicum</i> (Ch)        | 14                                   | 6        | 0        | 1.0               | -        |

For the year 1997, no germination was observed among the following species: *Limonium gmelinii*, *Karelinia caspica*, *Pseudosophora alopecuroides*, *Halostachys caspica* (Ch), *Haloxylon aphyllum* (Ch), *Suaeda microphylla* (Ch), *Salsola australis* (Ch) and *Halocnemum strobilaceum* (Ch)

Table 3: The table below demonstrates phytomelioration by seeding experiments on solonchak soil near Kaskakulan, twelve kilometres west of the former coastline. It was impossible to evaluate the germination percentage, but the number of plant individuals was taken into account. Seeding was undertaken in November 1997. Ch = Chenopodiaceae

| Plant                                | Quantity of Plants in Recorded Areas |          |          | Plant Height (cm) |          |
|--------------------------------------|--------------------------------------|----------|----------|-------------------|----------|
|                                      | 22/04/98                             | 01/06/98 | 23/08/98 | 01/06/98          | 23/08/98 |
| <i>Climacoptera aralensis</i> (Ch)   | 65                                   | 64       | 41       | 4.7               | 8.3      |
| <i>Haloxylon aphyllum</i> (Ch)       | 21                                   | 20       | 17       | 5.4               | 7.0      |
| <i>Climacoptera lanata</i> (Ch)      | 16                                   | 16       | 11       | 3.3               | 6.7      |
| <i>Salsola nitraria</i> (Ch)         | 24                                   | 23       | 8        | 1.5               | 4.5      |
| <i>Petrosimonia brachchiata</i> (Ch) | 17                                   | 16       | 3        | 2.2               | 3.3      |
| <i>Salsola australis</i> (Ch)        | 20                                   | 13       | 1        | 4.4               | 6.5      |
| <i>Suaeda microphylla</i> (Ch)       | 17                                   | 17       | 0        | 0.2               | -        |
| <i>Kalidium caspicum</i> (Ch)        | 9                                    | 4        | 0        | 1.0               | -        |

No germination was observed with *Halocnemum strobilaceum* (Ch)

- 5) Soil formation is dynamic and depends on local annual climatic conditions and long-term vegetation cover.
- 6) Vegetation changes are rapid and quite unpredictable. The creation of a viable seed bank would enable the vegetation to better adapt to the varying weather conditions.

Experiments in this area in the future will be performed on a larger scale by applying special techniques for promoting rainwater run-off and the accumulation of winter snow.

Large-scale soil improvement is not achievable, however, and the starting conditions for seedlings and saplings have to be improved by technical means. Planting saplings in hollows, to accelerate the colonization of bare soils, will complement seeding. Increasing vegetation cover will minimize sand and salt dust-storms.

Research then shows that vast quantities of water for leaching would be necessary to reclaim irrigated soils that strong salinization has devastated (Rau 2001). This can be only be feasibly achieved with reasonable economy on good soils in selected areas that are close to villages and towns, and by their conversion to intensive garden land.

### 3. Conservation

Two hundred and sixty-six vascular plant species have so far been recorded in the Aralkum Desert (Wucherer *et al.* 2001). Of these plants, 28.2 percent are *Chenopodiaceae*. This unique flora and the various combinations of new vegetation types present are in addition to the area's high biodiversity, which should be protected. The Barsakelmes State Reserve, an island reserve that was founded in 1939 as a nature reserve, and which has remained largely unchanged in the decades since then, represents the model for the vegetation and the main ecosystem types of the Aral Sea region.

Following the fall in the sea level over many years, the island resembles the former islands of Kaskakulan, Uzynkair and Akbastay, and today it is reduced to a flat hill. It would be very constructive to expand the protected areas to include territories of the exposed sea floor.

Setting up a network of regionally protected areas at the local authority level will conserve the biological diversity found in the natural environment.

To implement this, it is necessary that a larger area be designated as a national park. The area's fauna (which includes *Gazella subgutturosa*, *Equus hemionus*, and *Saiga tatarica* etc.), is partly recovering, and would also need to be under protection. This national park should also include an example of the Tugai forests found within the delta of the big rivers (Ogar 2001). This would be better achieved within the smaller Syrdarya delta, which has more constant water levels.

In addition to this, a water-conservation zone running along the whole Amudarya channel downstream to the Tyuamuyun dam would be required, in order to restore and protect the riverbank by developing riparian forests. The gallery forest belt stretching along the river should be one and a half to two kilometres wide (Novikova 2001, Treshkin 2001).

Land ploughing, cattle grazing, deforestation, firewood collection, construction work, and the discharge of wastewater into the river should be prohibited within this belt. To preserve the genetic and species diversity of the well-watered Tugai ecosystem, it is necessary to designate the Nurumtubek and Nazarchan Tugais and the new mouth of the Raushan Canal and the Kokdarya floodplains as nature reserves.

### Conclusion

The Aral Sea crisis is extremely complex. Only joint efforts at various levels can improve the environmental situation, and thus the socio-economic conditions of the inhabitants living in proximity to the crisis region. International developmental aid should not only be directed to specific economic projects, but should also be directed towards sustainable landscape planning, conservation, and capacity building.

Such development aid should enable people to become empowered, while seeking by themselves new ways to modernize agriculture and new management and economic systems that combine with water-saving techniques and the development of a more suitable energy supply (developing handicrafts or ecotourism industries, for example).

Other actions to improve the environmental situation in Kazakhstan are given in non-exhaustive lists alongside concrete examples by Karibaeva (2001) and Baitulin (2001). All of these actions take into account the need for the participatory involvement of communities and local populations for the conservation and rational utilization of natural resources.

As water needs and consumption in this region will increase in the near future, improved water- and energy-saving techniques have to be applied as early as possible. The only viable solution for all of the Central Asian states, not only for the Aralkum area, is to prevent severe water shortages, to use renewable energy sources, and to improve water efficiency and use by applying recycling techniques to used water. The most urgent task at hand is to halt secondary salinization that is caused by salt dust storms from the dry sea floor and the devastated old irrigation fields that are now totally salinized. Rehabilitation of these areas is vital. Research can substantially contribute to help solve these ecological questions and problems.

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# 11

## Rehabilitation of Degraded Drylands at Dingarh, in Pakistan's Cholistan Desert

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### Background

The total surface area of Pakistan is 79.6 million hectares, of which forty-one million hectares suffers from an arid climate, including eleven million hectares of desert land. The country's main deserts are the Thar, Cholistan, Thal and Chagi-Kharan. Land degradation caused by various factors is a common problem in the country, but the degree of land degradation is significantly worse in desert areas.

The Cholistan Desert consists of large sand dunes, small sand ridges, and flat plains and hollows, covering about twenty-six thousand square kilometres. The mean annual rainfall is low, variable and erratic and normally ranges from 100 to 250 mm. The major natural species in the area are *Calligonum*, *Haloxylon*, *Cymbopogon*, *Sindicus*, *Cenchrus*, *Prosopis*, *Tamarix*, and *Capparis*. The people and livestock depend on rainwater for drinking as groundwater is mostly saline. More than 98 percent of the desert area is affected by land degradation; due to poor vegetation cover, wind erosion and severe problems of salinity. Average summer and winter temperatures in the area range from 35.5°C to 46°C and 7°C to 18.0°C respectively. Occasionally, temperatures can exceed 50°C with a minimum temperature of just 1°C.

The desert area is divided into two parts. The Lesser Cholistan is a series of saline alluvial flats, alternating with low sand dunes making up an undulating to rolling topography, while dunes of the Greater Cholistan have rolling to moderate steep slopes. The height of dunes varies between 30 and 125 meters and the total area under dunes is 1.13 million hectares — making up 44 percent of the Cholistan Desert. Sandy soils make up 0.95 million hectares, or 37 percent of the Cholistan surface area. The sand is of varying depth, excessively drained, coarse textured and with a gentle topography. Areas of relatively flat clay soil, with poor vegetation, account for 0.442 million hectares or 17 percent of the Cholistan. These clay soils are shallow to moderately deep, impervious, saline sodaic and fine textured. Patches of loamy soils comprise only 2 percent of the Cholistan.

The majority of the land in the Cholistan Desert is used for grazing. Livestock includes sheep, goats, cattle, camels, and donkeys.

The primary source of fresh water in the Cholistan is rainwater. The rainwater during the rainy season is collected in natural depressions or man-made small ponds, locally called *tobas*. But these *tobas* supply water for a maximum of only three to four months a year, due to poor storage capacity, inappropriate catchments and considerable water loss in the form of seepage and evaporation. Desiltation of *tobas* is also not performed regularly, which further reduces their water-storage capacity. Groundwater, in wells, is the secondary source of water in the area. The quality of groundwater is mostly saline to brackish. However, it is used for drinking when *tobas* become dry.

The Pakistan Council of Research in Water Resources (PCRWR) established its two-hundred-hectare field-research station at Dingarh in the Cholistan Desert to conduct research relating to water resources and the rehabilitation of degraded lands for sustainable use. As a case-study to be multiplied on a large scale, water-resources development at Dingarh has rehabilitated degraded drylands through sand-dune fixation and stabilization, grassland development, range management, arid horticulture and silviculture, and rainwater harvesting and the conjunctive use of saline and fresh water for irrigation.

The area before rehabilitation was largely barren and devoid of vegetation as a result of wind erosion and random livestock grazing. This degraded land has become a biosphere reserve through the planting of trees, shrubs, grasses and bushes. The area has increased its overall vegetation by more than 80 percent. This has had the effect of halting wind erosion.

Today the station at Dingarh resembles a botanical garden, and no longer looks part of the surrounding desert. As a result of increased water, shade, food, and shelter, more wildlife — and particularly birds — can be seen in the area.

## 1. Land Degradation In Cholistan

The relationship between man and his environment has always been one of causal duality. Land provides a living space and has an economic function and it is also the source of most natural resources. Man is presently facing a looming ecological crisis; the problem of land degradation. Land degradation begins when any physical or biological entity is present in unusual or unnatural excess or shortage, making any part of the land undesirable for food cultivation, animal rearing or for recreation or aesthetic enjoyment.

Causes of land degradation in the Cholistan can be divided into two main classes: natural and manmade. Natural causes include low rainfall, high temperatures, and dry high-speed winds. Low rainfall reduces natural vegetation growth, and the Cholistan suffers from poor to moderate vegetation cover. In the absence of surface vegetation cover the soil is easily affected by wind erosion, resulting in land degradation. High temperatures during the summer also hinder plant growth, causing poor vegetation cover and further land degradation from wind erosion. High-speed winds during summer and winter accelerate the process of wind erosion, causing damage to good agricultural and rangelands. The other major causes of land degradation result from human activities, in the form of overgrazing cattle and the cutting of vegetation for fuel, timber and other activities.

The major land degradation agents in the Cholistan are sand migration, poor rangeland, and salinity / sodicity:

- **Sand Migration.** Sand and sand-dune migration in the Cholistan Desert is a result of wind erosion. The process becomes particularly severe during summer months when dry and barren soils are exposed to strong winds, the primary cause of drifting sand. Sandy soils and sand dunes are invariably non-coherent, excessively drained and lacking in structure. The poor physical characteristics of the soil enhance the process of wind erosion. Vegetation cover on the soil surface reduces wind velocity and thus diminishes the effects of wind erosion. Thus, wind erosion in the desert is severe during drought and dry conditions when vegetation cover is poor.
- **Poor Rangelands.** Grazing is the major use to which land in the Cholistan Desert is put, with a pattern of uncontrolled grazing resulting in overgrazing and a decrease in palatable species, causing a reduction in perennial vegetation. Watering points are not appropriately located or found at suitably frequent distances, with the result that livestock concentrate around water points — causing the destruction of pastures. Pastoralists have increased their herd sizes in many range areas without considering the carrying capacity of each range, resulting in overgrazing.

- **Salinity and Sodicity.** The total area affected by salinity and sodicity in Cholistan Desert is 0.442 million hectares, or 17 percent of the whole desert. The salts may be a result of the weathering of rocks, which are then transported to the area by carrying agents during certain periods. In harsh climatic conditions, salts may rise to the soil surface by capillary action from the mineralized groundwater or parent material. In the desert, rainfall is low, and with a high evaporation rate salts are not leached away and tend to accumulate near the soil surface. These soils are mostly barren or support sparse salt-tolerant vegetation.

## 2. Rehabilitating Degraded Drylands at Dingarh

### 2.1 DINGARH FIELD RESEARCH STATION

The PCRWR has established its two hundred-hectare field research station at Dingarh in the Cholistan Desert, seventy-five kilometres from Bahawalpur City, to conduct site-specific research on water resources and desertification control. The station area is representative of the main sandy deserts in Pakistan, and research on various aspects of the desert is carried out here. Research areas include rainwater harvesting, the conjunctive use of rain and saline water, sand-dune fixation and stabilization, rangeland development, afforestation, and the cultivation of salt-tolerant and drought-resistant grasses, forage crops, bushes, and shrubs. Before the establishment of the station, the area faced acute water shortages, as rainwater is the primary source of drinking water for humans and livestock while groundwater is mostly saline (drinking water is only available for three months of the year).

There was only one pond in Dingarh village for rainwater collection, and each tribe used saline groundwater in the form of open-dug wells for livestock. Disputes often arose among tribes because of water scarcity. The village habitually migrated with their livestock toward canal areas once the pond became dry and until the following rains. Due to the non-availability of water, shade, shelter, and food, wildlife was typically absent or very rare and the area was continually suffering the effects of active sand movements due to the absence of vegetation cover. It was very arduous and uncomfortable to stay there without trees or shade. There were no transit sites available for people traveling to other settlements in the desert where water, shade, and shelter were available.

### 2.2 WATER RESOURCES MANAGEMENT

As water grows scarce, the need for technical and scientific skills to remedy the situation increases. Water for drinking purposes among the human and livestock population

as well as for vegetation plantation can be provided by rainfall-harvesting techniques. As the population of the country continues to increase, the consequent increase in food supply will require the use of marginal and desert lands for farm production. Water-harvesting systems are the only way to supply fresh water in the deserts for domestic and other uses, particularly as alternatives are impossible or uneconomical.

### Freshwater Resource Development

Rainwater harvesting from suitable catchments can be used to supply water for domestic use and for livestock, wildlife, afforestation and crop cultivation. In the Cholistan Desert, runoff depends on the quantity of precipitation and the soil characteristics. The rainfall of the catchment area has been recorded regularly since 1989. Approximately 17 percent of the Cholistan area is flat with saline-sodic and impervious clay soils. These impervious soils can serve as the best catchment for rainwater harvesting and collection. The area has to be managed in order to enhance runoff and improve efficient water collection. An appropriate catchment area of ninety hectares, with

overall vegetation in the area as low as 10 percent, was identified by contour surveying for water harvesting and collection at Dingarh.

The catchment area is flat with dense saline-sodic clay soils, which are impervious and very poorly drained. The runoff in the catchment area has been increased substantially by developing a network of macro- and micro-ditches in the catchment area, as well as by clearing hummocks and vegetation that are obstacles to the flow of runoff. Ditches interconnect all the low-lying points in the catchment area. Six ponds have been dug to store harvested rainwater. These ponds collect rainwater within the shortest possible time and with minimum water losses. The storage capacity of the ponds varies between 2067 cubic metres and 18000 cubic metres. Each pond is connected with the main catchment through a network of ditches and channels that sift out the soil material brought from the catchment before reaching the pond. Seepage is minimized by spreading polyethylene sheeting on the pond floor, which is then covered with a dense impervious clay layer fifteen centimeters thick. The sides of the pond are also coated with clay. Evaporation

Table 1: Rainfall and runoff in ninety hectares of the Dingarh catchment and 0.442 million hectares of the Cholistan catchment.

| Year    | Annual Rainfall (mm) | Gross potential runoff over the catchment (mm) | Net potential runoff at Dingarh and Cholistan after deducting expected 37% water loss |                                     |
|---------|----------------------|------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------|
|         |                      |                                                | Dingarh (thousand m <sup>3</sup> )                                                    | Cholistan (million m <sup>3</sup> ) |
| 1989    | 84.2                 | 66.78                                          | 38                                                                                    | 186.0                               |
| 1990    | 144.1                | 109.97                                         | 62                                                                                    | 306.0                               |
| 1991    | 173.0                | 137.31                                         | 78                                                                                    | 382.0                               |
| 1992    | 218.6                | 189.5                                          | 107                                                                                   | 526.0                               |
| 1993    | 155.9                | 137.08                                         | 78                                                                                    | 382.0                               |
| 1994    | 298.8                | 275.85                                         | 156                                                                                   | 78.0                                |
| 1995    | 213.0                | 201.32                                         | 114                                                                                   | 561.0                               |
| 1996    | 152.0                | 135.45                                         | 77                                                                                    | 377.0                               |
| 1997    | 201.0                | 165.06                                         | 94                                                                                    | 460.0                               |
| 1998    | 172.0                | 143.39                                         | 81                                                                                    | 399.0                               |
| 1999    | 24.8                 | 10.73                                          | 6                                                                                     | 30.0                                |
| 2000    | 126.4                | 111.73                                         | 63                                                                                    | 311.0                               |
| 2001    | 146.2                | 123.79                                         | 70                                                                                    | 345.0                               |
| Average | 162.30               | 139.07                                         | 79                                                                                    | 387.0                               |

has been reduced by increasing pond depth and reducing surface area as well as by erecting mud walls and planting vegetation around the pond area. The rainwater harvested and stored by PCRWR at the Dingarh Field Research Station is used for domestic purposes and for livestock and wildlife, as well as for planting vegetation such as trees, bushes, and grasses. Annual rainfall and runoff available for harvesting at Dingarh and in the Cholistan catchments is given in Table 1 opposite.

### 2.3 CONJUNCTIVE USE OF GROUND SALINE WATER AND FRESH WATER OBTAINED THROUGH RAINWATER HARVESTING

In the desert, the availability of water for irrigation is fundamental to the rehabilitation of degraded drylands. The Dingarh area of the Cholistan Desert has no canals,

or other sources of fresh water apart from rainwater. Rainfall is low and cannot alone support the growth of trees, grasses, bushes, and crops. Groundwater as another source of water is also used for irrigation but unfortunately it is mostly saline. Therefore, the conjunctive use of rainwater and saline groundwater becomes necessary in order to irrigate plantations. A freshwater source has been developed at the station by harvesting rainwater and by obtaining saline groundwater using a ninety-metre deep turbine installed with a 0.5 cusec (cubic feet per second) discharge. The quality of the groundwater pumped by the turbine is moderately saline — EC 4.6<sup>dsm</sup>, SAR 14, RSC nil and pH 7.5. Rainwater is used for the irrigation of young plantations followed by irrigation by saline groundwater; rainwater and saline groundwater then continue to be applied alternatively.

Table 2: The shifting of sand in the protected and unprotected areas at Dingarh Cholistan Desert over a one-year period

| Protected Area |                   |                      |                                                   | Unprotected Area |                   |                      |                                                   |
|----------------|-------------------|----------------------|---------------------------------------------------|------------------|-------------------|----------------------|---------------------------------------------------|
| Plot           | Sand removal (mm) | Sand deposition (mm) | Vegetation cover within a radius of 30 meters (%) | Plot             | Sand removal (mm) | Sand deposition (mm) | Vegetation cover within a radius of 30 meters (%) |
| 1              | 0.0               | 0.0                  | 68.0                                              | 1                | 250.0             | 210.0                | 26.0                                              |
| 2              | 0.0               | 0.0                  | 73.0                                              | 2                | 700.0             | 40.0                 | 23.0                                              |
| 3              | 0.0               | 0.0                  | 77.0                                              | 3                | 220.0             | 570.0                | 38.0                                              |
| 4              | 300.0             | 60.0                 | 67.0                                              | 4                | 0.0               | 680.0                | 32.0                                              |
| 5              | 0.0               | 0.0                  | 51.0                                              | 5                | 2820.0            | 0.0                  | 44.0                                              |
| 6              | 220.0             | 80.0                 | 50.0                                              | 6                | 2260.0            | 0.0                  | 49.0                                              |
| 7              | 690.0             | 140.0                | 40.0                                              | 7                | 460.0             | 80.0                 | 66.0                                              |
| 8              | 900.0             | 140.0                | 51.0                                              | 8                | 1420.0            | 0.0                  | 62.0                                              |
| 9              | 0.0               | 0.0                  | 82.0                                              | 9                | 530.0             | 0.0                  | 70.0                                              |
| 10             | 0.0               | 0.0                  | 81.0                                              | 10               | 1471.0            | 0.0                  | 61.0                                              |
| 11             | 0.0               | 0.0                  | 64.0                                              | 11               | 1660.0            | 0.0                  | 39.0                                              |
| Average        | 134.54            | 38.18                | 64.0                                              | Average          | 1071.90           | 143.63               | 46.36                                             |

## 2.4 SAND-DUNE STABILIZATION AND RANGE DEVELOPMENT

The area selected for rehabilitation consisted of mobile sand dunes under the effect of active wind erosion and with sparse vegetation. Natural landscape and vegetation cover in the area was not disturbed. The land strips were leveled only where different tree species had to be planted. The young plantation was irrigated by mobile water tankers until the plants were well established. The plantation was then irrigated alternatively by saline and fresh water through channels and water tankers respectively. The area was fenced before plantation to prevent livestock grazing and other damage to the plantation. The surrounding area undergoing rehabilitation was also protected by erecting micro-windbreaks constructed from *Saccharum munja* and dry date stalks to reduce wind velocity at the soil surface, thereby minimizing sand movement from the adjoining areas. Mobile sands were fixed by erecting micro-barrier fences of plant material (Catalp) in a checkerboard form to create favorable conditions for the establishment of young plants and to reduce wind erosion on the surface area, thereby protecting the young plants against the abrasive action of strong summer winds and airborne sand. Different species of vegetation including trees, shrubs, bushes and grasses were planted to increase the vegetation cover on the soil surface. The main species of vegetation planted in the area were; *Acacia*, *Prosopis*, *Parkinsonia*, *Ampliceps*, *Zizyphus*, *Atriplex* spp. *Tamarix*, *Panicum*, *Sindicus*, and *Elusine*. Sand movement at Dingarh is summarized in Table 2.

The area of once-active sand dunes has been converted into good rangeland, with greater carrying capacity than natural grazing lands, by increasing palatable vegetation in the form of grasses, bushes, shrubs and trees.

To ascertain the improvement rate for range development, the site's vegetation was measured before rehabilitation began and after five and then twelve years. The average vegetation cover of the degraded land was less than 16 percent before rehabilitation. Following the plantation of vegetation and fencing, the overall of the

area increased by more than 80 percent. The tree species created a more favorable environment for the growth of natural vegetation species and also acted as windbreaks to protect the soil surface against strong summer winds. The natural vegetation became vigorous and began to appear on the vast areas that were originally bare. The area has been transformed into good rangeland with greater carrying capacity than the surrounding lands. More birds can be seen due to the availability of shade, food and shelter. The vegetation cover before the plantations were established and fencing was installed was between 10 percent and 32 percent, now it is between 73 percent and 93 percent. The changes in vegetation cover and plant species at Dingarh are shown in Table 3 and Table 4.

## 2.5 SILVIPASTURE GRASSLAND DEVELOPMENT

The PCRWR developed five hectares of previously sandy land as grassland at the Dingarh Field Research Station as a model site. The land was recovered and prepared for cultivation with different species of grasses. The texture of the soil horizons in the area ranged from coarse to fine textured. The main grass species cultivated were (1) *Lasiurus indicus* (gorkha), (2) *Cenchrus ciliaris* (dhamen), (3) *Panicum antidotale* (murret), (4) *Jangli bajra* (wild millet). In addition to grasses, fodder trees such as *Acacia* and *Prosopis* were planted in rows at fifteen-meter intervals.

The grasses were irrigated with saline groundwater at fixed intervals, depending on soil moisture and temperature and varying on a weekly, fortnightly or monthly basis. The salinity level of the irrigation water was EC 4.6 d Sm<sup>-1</sup>, SAR 14 and RSC nil. Soil-management practices such as constructing ridges, hoeing and adding Gypsum were also adopted occasionally to minimize adverse salt effects on the plants and the soil. The dry biomass of the cultivated grassland and the natural grazing land was recorded to determine the lands' carrying capacity for livestock. The natural grazing land produced 1141 kg of dry biomass per hectare, whereas the cultivated grasses *Cenchrus ciliaris*, *Panicum antidotale*, *Lasiurus indicus*

Table 3: Change in vegetation cover at Dingarh, Cholistan Desert after rehabilitation of degraded drylands, percentage

| Traverse No                                   | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | Average |
|-----------------------------------------------|----|----|----|----|----|----|----|----|----|----|----|---------|
| Before fencing and plantation (1988)          | 10 | 14 | 15 | 22 | 18 | 25 | 32 | 26 | 27 | 27 | 20 | 21.45   |
| Five years after fencing and planting (1994)  | 85 | 75 | 90 | 96 | 96 | 93 | 90 | 98 | 92 | 95 | 90 | 90.90   |
| 12 years after fencing and plantation (2001)* | 87 | 75 | 89 | 86 | 74 | 87 | 93 | 83 | 73 | 89 | 81 | 83.36   |

(\*)There was a severe drought in 1999—2000

Traverse length = 1100 feet.

Distance between each traverse = 100 feet.

Table 4: Plant species and plant stubbles in the protected and unprotected areas at Dingarh Cholistan during the drought period in the year 2000 (Plot Size: 10 X 10 = 100m<sup>2</sup>)

| Sp.No | Name Of Species                       | Protected Areas                           |    |    |    |    |   |    |    |    |    | Unprotected Areas               |   |    |   |   |    |   |   |    |    |
|-------|---------------------------------------|-------------------------------------------|----|----|----|----|---|----|----|----|----|---------------------------------|---|----|---|---|----|---|---|----|----|
|       |                                       | Total Number of Plants/Stubbles Locations |    |    |    |    |   |    |    |    |    | Total Number of Plants/Stubbles |   |    |   |   |    |   |   |    |    |
|       |                                       | 1                                         | 2  | 3  | 4  | 5  | 6 | 7  | 8  | 9  | 10 | 1                               | 2 | 3  | 4 | 5 | 6  | 7 | 8 | 9  | 10 |
| 1     | <i>Lasiurus indicus</i> (gorkha)      | 2                                         | -  | -  | -  | -  | - | -  | -  | -  | -  | 1                               | - | -  | - | - | -  | 2 | - | -  | -  |
| 2     | <i>Haloxylon salicornicum</i> (lana)  | 15                                        | 12 | -  | -  | 16 | 3 | -  | -  | 2  | -  | 6                               | 4 | 12 | - | 1 | 9  | 3 | 2 | 4  | -  |
| 3     | <i>Calligonum polygonoides</i> (phog) | 1                                         | -  | -  | 2  | 2  | - | 2  | -  | 1  | -  | 1                               | 1 | 1  | - | - | 2  | 1 | 1 | 1  | -  |
| 4     | <i>Cymbopogon jawarancusa</i> (khavi) | 15                                        | 5  | -  | 5  | -  | - | -  | -  | 2  | -  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 5     | <i>Cenchrus ciliaris</i> (dhamen)     | -                                         | 19 | 3  | -  | -  | - | -  | -  | 22 | -  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 6     | Stubble of dead vegetation            | -                                         | -  | -  | 1  | 5  | - | -  | -  | -  | -  | 4                               | 2 | 3  | 1 | - | 2  | 3 | 5 | 6  | 7  |
| 7     | <i>Panicum</i> (bansi grass)          | -                                         | -  | -  | 16 | -  | - | 25 | -  | -  | -  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 8     | <i>Zizyphus</i> (ber)                 | 5                                         | -  | -  | 3  | -  | - | -  | -  | -  | 1  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 9     | <i>Tribulus terrestris</i> (bhakhri)  | -                                         | 5  | 2  | -  | -  | - | -  | 13 | -  | 9  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 10    | <i>Ampliceps</i>                      | -                                         | -  | 9  | -  | 9  | 3 | 4  | 8  | -  | 8  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 11    | <i>Acacia</i>                         | -                                         | -  | -  | 10 | -  | 2 | 2  | -  | 3  | -  | -                               | - | -  | - | - | -  | - | - | -  | -  |
| 12    | <i>Caparis</i> (karir)                | -                                         | -  | -  | -  | -  | - | -  | -  | -  | -  | -                               | - | -  | 1 | - | -  | - | - | -  | -  |
|       | Total                                 | 38                                        | 41 | 14 | 37 | 32 | 8 | 33 | 21 | 30 | 18 | 12                              | 7 | 16 | 2 | 1 | 13 | 9 | 8 | 11 | 7  |

and wild millet, irrigated with saline water, produced 15012 kg, 12407 kg, 18274 kg and 38780 kg per hectare of dry biomass respectively. In Cholistan, the carrying capacity of natural grazing land is 1.25 sheep per hectare annually. However, cultivated grasses irrigated by saline water produced ten to thirty-five times more dry biomass per hectare than grasses under natural conditions. This suggests that if desert lands could become grassland through irrigation by saline water, the carrying capacity for livestock could be improved by ten to thirty-five times that of natural desert lands.

## 2.6 MUSTARD CULTIVATION UNDER SALINE WATER IRRIGATION

Mustard (*Desi raya*) has been grown on sandy soils at Dingarh with two treatments of saline water at a quality equal to EC 4.6 dSm<sup>-1</sup>, RSC nil, SAR 14 and pH 7.5. The crop was cultivated in November and harvested in April. The crop yielded five hundred kilogrammes per hectare and developed well, considering its irrigation by saline water and the harsh climatic conditions, compared to more favorable climatic conditions and freshwater irrigation. This experiment demonstrated that mustard can be grown as an oil and fodder crop on deep sandy soils with moderately saline water. The soil samples, before crop sowing and harvesting, were analyzed for salinity, which was shown to have decreased where salts had been leached by irrigation due to the porous layer of the soil profile. Salinity was shown to have increased where salts had been deposited after irrigation because of the low permeability of the soil profile.

## 2.7 ARID HORTICULTURE THROUGH CONJUNCTIVE IRRIGATION

More than five hundred *Zizyphus* and grafted *Zizyphus* and two hundred date trees were planted along the main and small channels that were irrigated conjunctively with saline groundwater and fresh water collected in the ponds. The trees have developed well, reaching a height of more than three meters, with most bearing fruit.

## 2.8 JOJOBA CULTIVATION AT DINGARH

The PCRWR planted jojoba (hohoba) on a one-hectare site of desert dune land at the Dingarh Field Research Station in the Cholistan Desert, to test its adaptation to desert conditions when irrigated conjunctively with rainwater (quality; EC 0.58 dSm<sup>-1</sup>) and moderately saline water (EC 4.6 dSm<sup>-1</sup>, SAR 14, RSC nil and pH 7.5). Approximately one hundred plants are now ten years old. These have attained a height of up to three meters and bear fruit. Other plants have been planted on the site more recently. Jojoba is a bushy tree that grows between two and four meters in height, with roots found at a depth of twenty metres in porous soils. The natural lifespan of jojoba is between one hundred and two hundred years under good climatic

and soil conditions, and it can bear fruit from the age of three years. The jojoba fruit takes about six months to mature (the seed contains more than 50 percent oil). The plant maintains its light- to dark-green color throughout the year.

## 3. The Current Situation of the Dingarh Drylands

Before rehabilitation, the Dingarh area was mostly bare or presented only patchy, sparse vegetation. Fencing and the planting of trees, shrubs, grasses, and bushes increased the overall vegetation cover of the area by more than 80 percent. This improvement in vegetation cover on the bare soils reduced wind erosion by over 95 percent. Today, the area resembles a healthy forest and the rangeland has greater carrying capacity than the lands surrounding the test site. Lands made up of mobile dunes have been transformed into rangeland, with sparrows feeding on the grasses.

Different *Atriplex* (salt bush) species were introduced in the area to stabilize mobile sands and to provide forage for sheep, goats and camels. These species are well established and have improved the land's carrying capacity. Fruit-tree plantations of date and *Zizyphus* have become well established. Mustard crops have produced a good yield in the saline environment. Today, the rehabilitated area resembles an irrigated area at the desert periphery and does not seem part of the desert itself. More wildlife can be seen and bees are producing honey from the flowers of the various tree species. This previously degraded land has been rehabilitated — it is no longer under threat from land-degradation processes. In addition, the leaves, grasses, bushes and tree twigs are adding raw material to the soil, improving its organic matter as well as other physical properties.

## Conclusion

Degraded desert lands in the Cholistan Desert can be transformed into good productive lands by the simultaneously management of water, soil and plant resources.

Livestock production in the Cholistan Desert can be increased manifold by providing good-quality water and by increasing the carrying capacity of rangelands and grasslands.

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# 12

## Features of Dryland Rehabilitation in the Republic of Kalmykia, Russia — Observations in the Chernye Zemli Biosphere Reserve and the Adjacent Territory

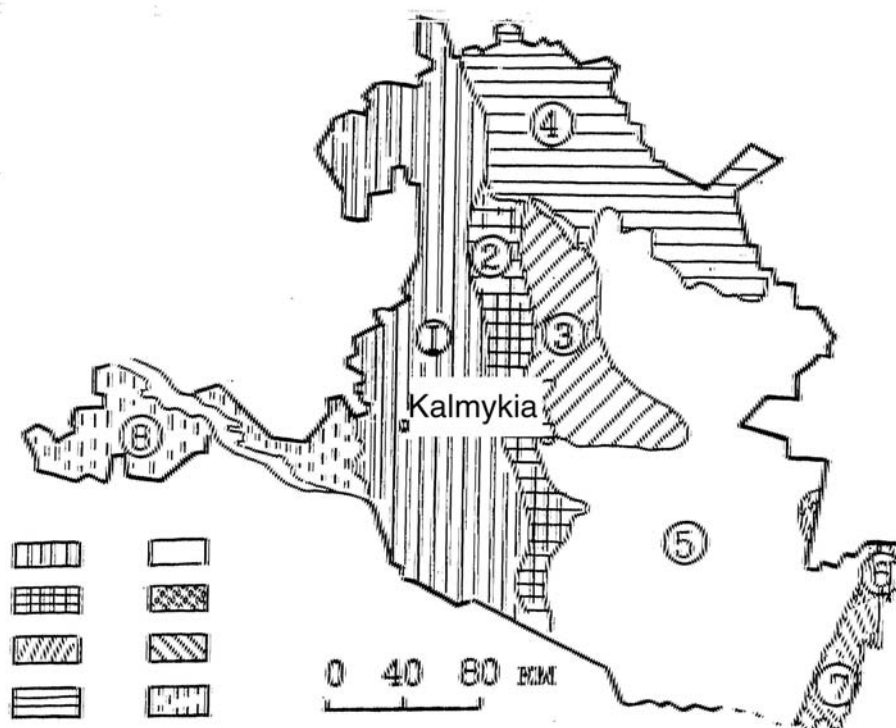
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There are currently seventeen regions making up the Russian Federation, most of which are affected to some extent by desertification. The most severely affected is the Republic of Kalmykia, where a desert area of more than one million hectares was identified towards the end of the 1980s. The majority of the desertified areas are in the Chernye Zemli district of Kalmykia (Figure 1), where the State Reserve Chernye Zemli was established in 1990 and became part of the World Network of Biosphere Reserves in 1993. Within the Chernye Zemli district and the surrounding areas, 47.3 percent of the surface area suffers from various stages between severe and very severe desertification. However, aerial photos and recent analysis

of the results of long-term field research show the sharp improvement in the state of pasturelands in this area, with desertification stages down by 13.3 percent (Andreeva and Kust, 1998, Borlikov and Bananova 2001).

In 1980, the Institute of Ecology and Evolution at the Russian Academy of Sciences began a complex scientific project to study the processes of desertification and the rehabilitation of drylands in Kalmykia, work that continues today. Results of the studies undertaken in and around the Chernye Zemli Biosphere Reserve have been published in many journals (mostly in Russian), summarized recently by Shilova *et al.*, 2001 and Neronov, 2002. My presentation is mainly based on these papers.

*Figure 1. Map of Kalmykia (from Tsatsentkin et al., 1952):*



1. Ergeny hills; 2. Pre-Ergeny inclined plain; 3. Davan hollow; 4. Sarpa depression; 5. Chernye Zemli; 6. Ilmen-Predelta district; 7. Maritime district; 8. Western Manych; 9. Chernye Zemli Biosphere Reserve.

The studies conducted reveal that the main characteristics of the local arid ecosystems are dependent on the livestock pasture load. In the past, up until the mid 1980s, the results of uncontrolled and excessive livestock grazing transformed the territory of Chernye Zemli into an ecological catastrophe, and it was declared the first man-made desert in Europe. Since the 1980s, the process of desertification has reversed with wide-ranging vegetation recovery. Changes in the economic activities of the region — for example, a sharp reduction in the number of pastured cattle from 2,500,000 to 650,000 head in Kalmykia (Figure 2) — has resulted in soil stability and increased vegetation cover as well as provoking a change in the climatic cycle from 209 millimetres of precipitation per year to 420 millimetres. Turf-forming grasses (*Stipa spp.* and others) have dispersed over the large territory in Kalmykia, beginning a process of steppization (Neronov 1998). It should also be mentioned that in some cases this has resulted in an increased frequency of wild steppe fires, which could prevent the recovery of native semi-desert plant communities.

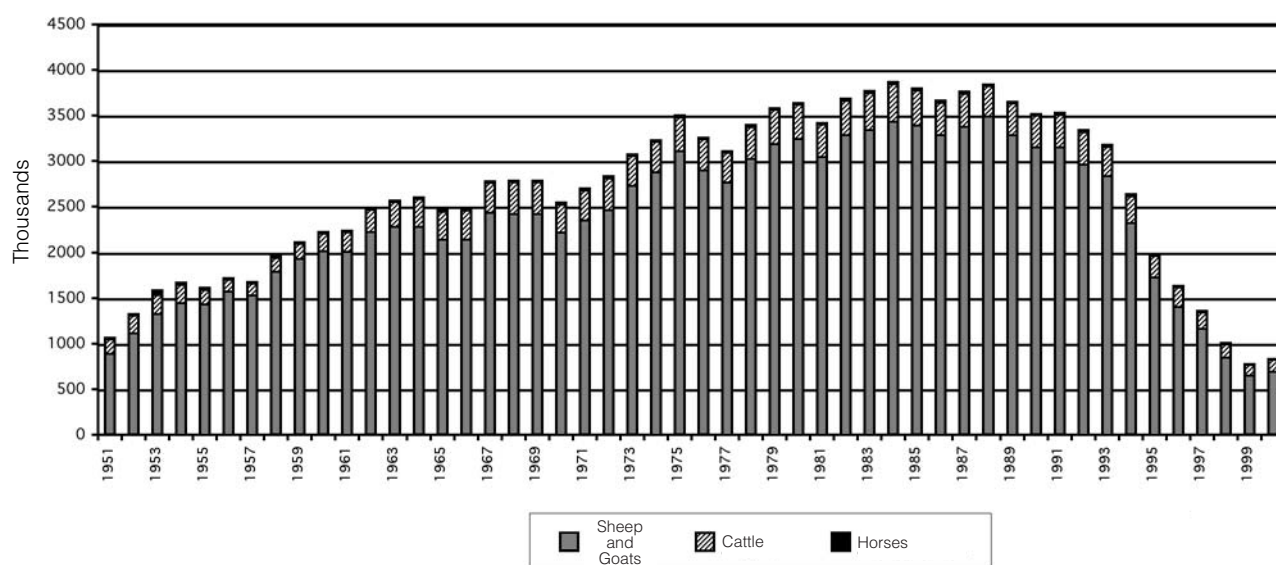
Some rodent populations (*Meriones meridianus*, *M. tamiaciscinus*, *Microtus socialis*, *Spermophilus pygmaeus*, *Mus musculus*) inhabiting this territory have been rendered inert to rapid changes of vegetation succession observed in their habitats, as shown by analysis of their behavior under these conditions. As the structure of restored ecosystems can be damaged in the short term from increasing numbers of livestock, it is important to take into account the scientifically based proposals recommended for the future sustainable development

of the economy in this area and in the whole of the Kalmykia Republic. Only then is it possible to make long-term plans for the use of pastures, so as to maintain a healthy livestock population while making it possible to enlarge the pasture lands' capacities.

Last year Kalmykia saw the presidential target program "Restoration of Conventional Pasture Animal Raising" for the years 2001–2010 approved by decree by the president of the Republic of Kalmykia. The program's main objectives are to preserve arid-zone land resources in southern Russia and to create the right conditions for the sustainable development of agricultural-based restoration of conventional ranching and the revival of unique Kalmyk animal breeds (fat-tail sheep, camels, beef-dairy cows, and horses). As a result of the implementation of this program, pastures will be conserved and restored and their further desertification halted and prevented in the future. Also, preparations have begun to increase the network of protected areas for the conservation of the unique ungulate-saiga antelope (*Saiga tatarica*) that inhabit the Kalmykia drylands, and for the designation of the whole district of Chernye Zemli as a site of world importance (within the special wwf international program "The Living Planet").

Public awareness initiatives based on examples of farming best practices in arid regions have increased. The most obvious examples of practical solutions to these issues include the regular publication of the *Steppe Bulletin*, dedicated to the conservation of the steppe ecosystem and promotion of the non-destructive use of natural resources in the steppes. Since the year 2000, two

Figure 2. Livestock Population in Kalmykia, 1951–2000.



similarly focused magazines entitled *The Open Country* (in English) and *Steppovedeniye* (in Russian) are being published. Two years ago in Kalmykia, Mr. Sam Bingham organized a special course on holistic management, and several participants were given a chance to visit the United States of America to continue training in practical methods to halt desertification processes and to increase pasture capacity.

The normative legal base for biodiversity conservation and sustainable development of agriculture in arid regions of Russia is founded on international agreements and conventions of which Russia is a signatory member. Although Russia has yet to sign the *United Nations Convention to Combat Desertification*, the country has instigated several fundamental and important laws regarding nature conservation generally and the conservation of arid regions in particular: "On Environmental Protection" (1991, 2002), "On the Animal World" (1995) and "On Protected Areas" (1995). Presently, the state parliament, the Duma, is working on a new federal law "On Soil Conservation", which is intended to regulate the interaction of actors responsible for soil conservation and aims to prevent soil degradation and pollution so as to maintain its natural regulation and its ecological and economic functions. The Land Code of Russia was adopted in 2001 and should be used in the future to improve land use, particularly among private farms, and to prevent further land degradation throughout Russia and the desertification of land in the southern regions.

## Session III: Networking, Information Exchange, and Databases

# 13

### Preparation and Implementation of Sub-Regional Action Programmes to Combat Desertification in West Asia

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#### Introduction

Since 1995, the United Nations Environment Programme Regional Office for West Africa (UNEP-ROWA), together with support from the United Nations Convention to Combat Desertification (UNCCD) secretariat, the Global Mechanism of the UNCCD (GM-UNCCD), the Council of Arab Ministers Responsible for Environment (CAMRE), the Gulf Cooperation Council, the Islamic Development Bank, and other organizations and member countries in the West Asia region, have been engaged in the preparation of the West Asian sub-regional programme. A Sub-Regional Action Programme (SRAP) was drawn up to combat desertification through a consensus-building process. Member states agreed that UNEP-ROWA should serve as the Regional Coordinator for the SRAP. Two thematic networks were established: sustainable water management and the sustainable management of vegetation cover. Benchmark indicators for the effective performance of the SRAP were also identified.

UNEP-ROWA provided assistance to a number of countries in the West Asia region to prepare their National Action Programmes (NAPS). The assistance involved actions to raise awareness and included consultations on programme matters. In 2001, a workshop was organized in Riyadh, Saudi Arabia, to assist GCC countries in preparing their NAP, including the preparation of guidelines for its development. In addition, a focal point meeting for Arab States in 2001 in Salalah, Oman, was organized to assist in the preparation and implementation of NAPS and the SRAP and, more specifically, to provide technical assistance to two countries in preparation of their NAPS as well as offering technical support to Kuwait, The United Arab Emirates, and Palestine in preparing their first national reports.

As coordinator of the West Asia Sub-Regional Action Programme, UNEP-ROWA has also been undertaking the following actions towards implementing the SRAP and combating desertification in this region.

#### 1. Design Phase

The member states of West Asia together with the United Nations Convention to Combat Desertification (UNCCD) secretariat and international and regional organizations have been engaged for over six years in the process of formalizing the Sub-Regional Action Programme to Combat Desertification and Drought for West Asia. Discussions between the West Asian countries began in Bahrain in 1995 and continued in Abu Dhabi in 1996, Damascus in 1997, and Muscat in 1998.

A joint draft proposal for several networks was prepared and presented by the Arab Center for the Studies of Arid Zones and Drylands (ACSAD), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Centre for Environment and Development for the Arab Region and Europe (CEDARE), which was subsequently discussed during the Muscat meeting in 1998. As a result of the Muscat meeting, the Global Mechanism began implementing the recommendations in 1999 through a series of consultations. The views and comments expressed by the countries and regional and international organizations were used to finalize the SRAP document. At a meeting in Dubai in February 2000, the text was adopted and endorsed by the member countries. The SRAP contains two thematic networks, one for Sustainable Water Management (TN1) and the other for the Sustainable Management of Vegetation Cover (TN2).

#### 2. Pre-Implementation Phase

In meetings of the management committee in Bangkok and Bonn in November and December 2000, ICARDA and ACSAD were requested to prepare initial proposals for an inventory study and a mechanism to establish two regional databases on water resources and vegetation cover to combat desertification in West Asia. The SRAP Management Committee approved the two proposals in

March 2001 and requested that ACSAD and ICARDA develop an integrated pilot project proposal for the management of water resources and vegetation cover.

### 3. Implementation Phase

UNEP, as regional coordinator, has signed a letter of agreement with the General Mechanism, which will make available US\$150,000 to support SRAP implementation in West Asia. ICARDA and ACSAD approved a letter of agreement outlining the funding mechanism for the implementation of the inventory studies and regional databases on sustainable water and vegetation-cover management. The project was implemented in accordance with these objectives, activities, and expected results. UNEP, ICARDA, and ACSAD will also prepare a feasibility study for pilot projects to combat desertification in mountainous, rangeland, and coastal areas. The work undertaken for both the inventory and feasibility studies began in September 2001 and will be completed by April 2003. Other considerations include:

- Facilitating OPEC commitment of US\$350,000 for UNCCD pilot activities in six countries in West Asia.
- Preparing a feasibility study on the implementation of pilot projects in West Asia begun in 2002.
- UNEP-ROWA involvement in developing a draft project proposal for sustainable development in rain-fed areas in the WANA region.
- Linking SRAP activities with regional action programmes for Asia that address the following priority areas:
  - a) desertification monitoring and assessment;
  - b) agro-forestry and soil conservation in arid, semi-arid and dry sub-humid areas;
  - c) range management and fixation of shifting sand dunes;
  - d) managing water resources for agriculture in arid, semi-arid and dry sub-humid areas;
  - e) strengthening capacity to mitigate the impact of drought and to combat desertification;
  - f) assistance for the implementation of integrated local area development programme initiatives.

In collaboration with ICARDA and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the follow-up to the project "Wind Erosion in Africa and Western Asia — Problems and Control Strategies" was completed in 1999. Also, *A Brief Study on Desertification*, based on the World Atlas of Desertification, was published in Arabic in 1999 with support from the Zayed International Prize for the Environment.

UNEP-ROWA, CAMRE and ACSAD prepared a study published under the title of the *State of Desertification in the Arab Region*, which included ways and means to deal with

the problem. It was published in Arabic and summarized in English in 1996. This study will be updated this year by UNEP-ROWA and ACSAD.

Since 2001, UNEP-ROWA, the United Nations Development Programme in Yemen (UNDP-Yemen), and ACSAD have been providing technical support to Yemen in the field of combating land degradation to ensure sustainable use of Yemen's natural resources.

# 14

## Developing Synergy Between ROSELT-OSS and UNESCO-MAB Networks

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Most Sahara-Sahel Observatory (*Observatoire du Sahara et du Sahel*, or OSS) member states are also members of UNESCO. They are affiliated with ROSELT-OSS (the OSS's Long-Term Ecological Observatories Monitoring Network, or *Réseau d'Observatoires de Surveillance Ecologique à Long Terme*) and participate more or less actively in the UNESCO-MAB (Man and the Biosphere) programme. This means that certain ROSELT-OSS observatories are also biosphere reserves — including the national parks of Bou Hedma in Tunisia, Boucle du Baouli in Mali, Tassili n'Ajjar in Algeria, and El Omayed in Egypt.

One of the main objectives of ROSELT-OSS is to gather information and heighten knowledge on resource-degradation processes and the interaction between resources and resource use, through long-term ecological monitoring that includes socio-economic parameters. MAB biosphere reserves aim to combine the conservation of natural resources with their sustainable use. This approach leads to the special zoning of these reserves: a strictly protected core area, a surrounding buffer zone (or management zone), which helps protect the core area, and a transition zone (or development zone) surrounding the two preceding zones, where various resource-management practices are developed with the local population.

ROSELT-OSS monitoring activities are generally carried out in the buffer and transition zones. However, the inclusion of observation data from the protected core zones could prove very useful in bringing together knowledge on resource-degradation mechanisms, particularly when considering the increasing gradient of exploitation, from zero exploitation in the core zone to maximum exploitation in the transition zones.

Observation data is admittedly not adequately reported in the four sites common to the MAB and ROSELT-OSS networks. The national teams responsible for managing the MAB reserves and the teams working on ROSELT-OSS each tend to work independently. There is a need for greater collaboration between these national teams to coordinate their activities and to make better use of their data and information in developing decision-making tools.

### 1. Introduction

At the international level, environmental considerations and the growing awareness of the dangers of perpetual and accelerated degradation of natural resources threatening humanity are giving increasing cause for concern. Major programmes around the world are being devoted to studying, monitoring and protecting the environment, seeking mainly to improve natural-resources management, environmental surveillance and protection, and particularly desertification control.

Certain programmes are already cooperating and combining efforts, others need to establish or strengthen links to further disseminate available information and develop standardized, mutually planned, common databases on the environment, with a view to coordinating approaches towards desertification control, water-resources management, and soil protection.

With this in mind, OSS programmes (in particular through ROSELT) and programmes of the UNESCO Ecological Sciences Division (in particular those focusing on arid zones conducted under the MAB programme) have many converging objectives (conservation, protection, sustainable development) and objective-related activities (ecological monitoring, ecosystem studies, decision-support). Synergy between these two programmes should be strengthened to more efficiently capitalize on the available information.

### 2. The Roselt/Oss Programme

ROSELT-OSS represents the first network in Africa to organize scientific environmental monitoring in order to characterize the causes and effects of natural-resources degradation and to obtain a better understanding of the mechanisms that lead to desertification.

The basic objectives of ROSELT-OSS are:

- long-term surveillance of the evolution of ecological systems;

- understanding the interactive functioning of local populations and their environment at the local level,
- determining the interactive roles played by the climatic and man-made causes of land degradation in particular.

ROSELT-OSS is both a tool and a scientific framework for desertification monitoring-evaluation and surveillance mechanisms needed for the National, Sub-Regional and Regional Action Programmes (NAPS, SRAPS, RAPS) as advocated in the United Nations Convention on Combating Desertification (UNCCD). The ROSELT-OSS labeled observatories together form a network of territories representing the main ecotypes in the circum-Saharan region, in which research programmes are undertaken that meet with objectives for sustainable development.

The ROSELT-OSS network operates under short- and medium-term concerns, but must also ensure permanency of the long-term surveillance mechanism. It was primarily designed to:

- produce reliable, coordinated databases with information on the “state of the environment”;
- improve knowledge on ecological systems dysfunctioning and the mechanisms of desertification;
- evaluate the impact of development and the actions employed to control desertification;
- identify methods and techniques for environmental rehabilitation and the rational management of natural resources;
- compensate for the lack of reliable information on desertification issues and the ecological, agro-ecological and socio-economic consequences of desertification.
- transfer knowledge and disseminate information making it accessible for people working in the development sector.

As part of the OSS circum-Saharan Africa intervention zone, twenty-nine observatories have been labeled, of which fourteen are operating as part of a ROSELT-OSS pilot project network.

Table 1: Main Activities of MAB and ROSELT-OSS

|                                                                                                                                     | MAB | ROSELT |
|-------------------------------------------------------------------------------------------------------------------------------------|-----|--------|
| Conservation activities:                                                                                                            |     |        |
| o Conservation of landscapes, ecosystems and biological diversity                                                                   | X   | X      |
| o Conservation of genetic biodiversity                                                                                              | X   |        |
| Development activities:                                                                                                             |     |        |
| o Promotion of economic development and preservation of socio-cultural heritage                                                     | X   |        |
| o Promotion of economic and human development and environmental protection                                                          |     | X      |
| Co-logistical support — continuous research and surveillance of:                                                                    |     |        |
| o abiotic factors contributing to the causes and effects of desertification (climatology, hydrology, geomorphology, pedology, etc.) | X   | X      |
| o Biotic factors:                                                                                                                   |     |        |
| - flora                                                                                                                             | X   | X      |
| - fauna                                                                                                                             | X   | X      |
| o Socio-economic factors (demography, economics, traditional wisdom, etc.)                                                          |     | X      |

### 3. The MAB Programme and the Concept of the Biosphere Reserve

The biosphere-reserve concept is implemented and coordinated by the UNESCO-MAB secretariat. It draws attention to opportunities to link conservation efforts and development issues in order to improve biodiversity conservation in protected zones. Development measures designed to improve the living standards of the local population must be combined with efforts to alleviate pressure on the environment in order to be successful. Biodiversity management entails both the conservation and preservation of biodiversity and encouraging sustainable development through the rational use of resources.

Biosphere reserves are demarcated to include protected core zones. These central areas are representative of ecosystems that are typically found in the region and whose intrinsic value has been recognized. The core zones also provide scientists and administrators the opportunity to study the structure and functioning of these ecosystems, which enables an understanding of their dynamics.

Countries nominating sites as biosphere reserves are confirming their determination to adopt the integrated approach of conservation and development while becoming part of an international network that will allow them to benefit from the sharing of information and experiences of sites whose ecological conditions and/or socio-economic conditions are comparable.

*Table 2: Activities conducted through the programmes at the Bou Hedma site in Tunisia*

| ROSELT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | MAB                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Long-term surveillance activities:</p> <ul style="list-style-type: none"> <li>o Constructing/updating land-occupancy map</li> <li>o Monitoring climatic parameters,</li> <li>o Monitoring the conditions of the soil surface</li> <li>o Monitoring vegetation</li> <li>o Monitoring fauna</li> </ul> <p>2. Researching desertification mechanisms:</p> <ul style="list-style-type: none"> <li>o The impact of climatic change on the environment</li> <li>o The impact of man-made activities on the environment</li> <li>o The interaction between ecological systems and social systems</li> <li>o Finalizing and/or experimenting with environmental information systems and methodology with which to approach the mechanisms of desertification</li> </ul> <p>3. Preparing decision-making and development support tools:</p> <ul style="list-style-type: none"> <li>o Environmental studies to support development projects</li> <li>o Desertification indicators</li> <li>o Biodiversity indicators</li> <li>o Thematic reports and maps</li> </ul> | <ul style="list-style-type: none"> <li>o Constructing an inventory of flora and fauna</li> <li>o Researching ecophysiology and genetics of main plant species</li> <li>o Studying soil/plant/animal interactions</li> </ul> |

## 4. Proposal for Creating Synergy between the Two Programmes

UNESCO-MAB and ROSELT-OSS are developing synergy among their two programmes in order to avoid duplication of efforts. By coordinating their efforts they will create opportunities for improved communication channels and more efficient information use.

### 4.1 JOINT ACTIVITIES

The main functions assigned to MAB's biosphere-reserve network and the orientations being prioritized for its future development are akin to those of the ROSELT-OSS network. There are many similarities among the activities carried out by UNESCO-MAB and ROSELT-OSS, in particular the actions relating to:

- the surveillance and protection of fragile ecosystems and environments;
- the conservation of plant and animal species.

### 4.2 COMPLEMENTARY ACTIVITIES

Table 1 on page 70 gives information on the complementarity between the main activities of the two networks, MAB and ROSELT-OSS.

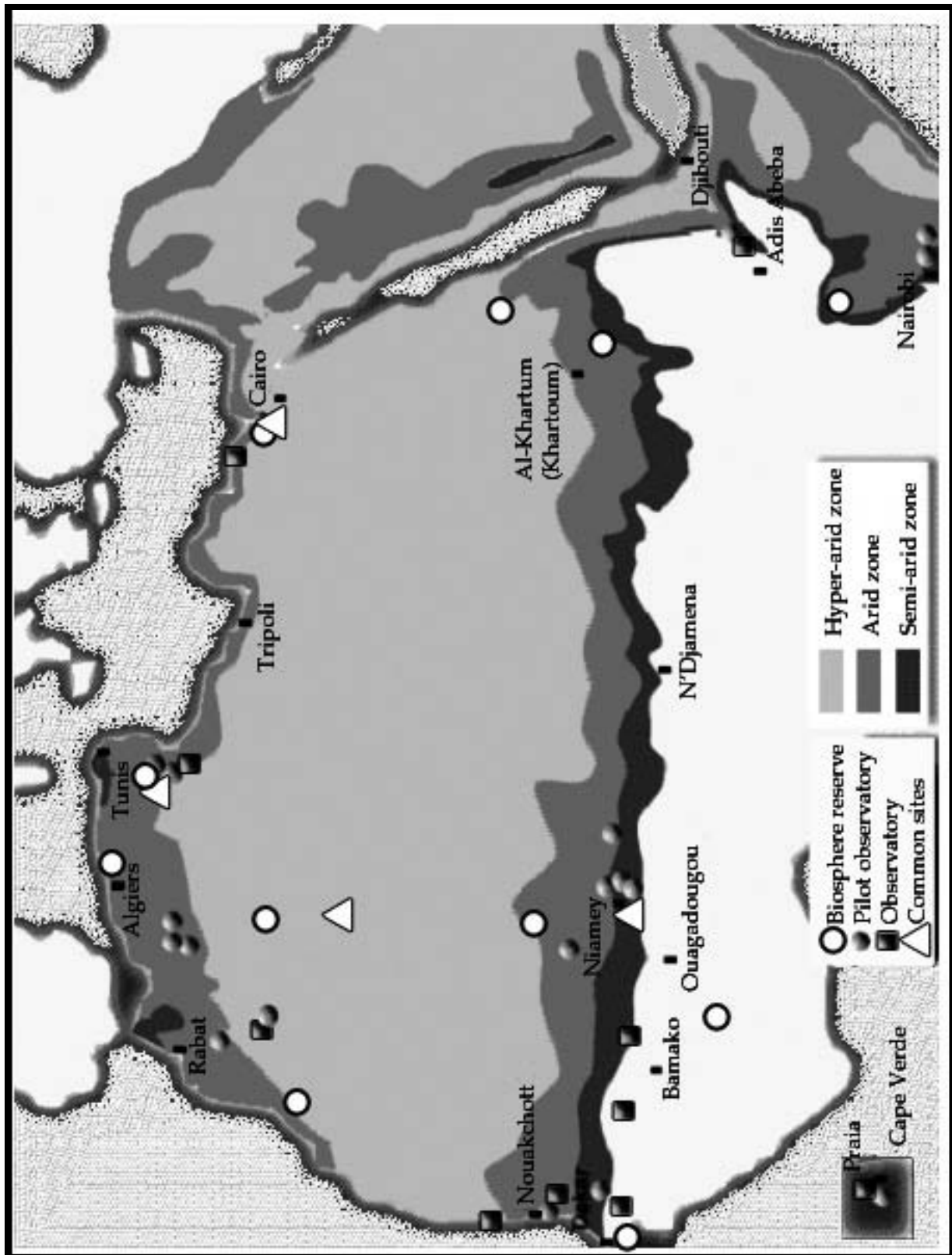
### 4.3 COMMON SITES

The ROSELT-OSS observatories, ecologically-monitored geographic areas, meet overall criteria that qualify them as biosphere reserves. Four ROSELT-OSS observatories have already been accepted by the MAB programme: Bou Hedma in Tunisia; El Omayed in Egypt; Tassili n' Ajar in Algeria; and Boucle du Baoulé in Mali.

*Table 3: activities conducted through the programme at the El Omayed site in Egypt*

| ROSELT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | MAB                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Long-term surveillance activities:</p> <ul style="list-style-type: none"> <li>o Constructing/updating land occupancy map</li> <li>o Monitoring climatic parameters,</li> <li>o Monitoring the conditions of the soil surface</li> <li>o Monitoring vegetation</li> <li>o Monitoring fauna</li> <li>o Monitoring usage and socio-economic studies</li> </ul> <p>2. Researching desertification mechanisms:</p> <ul style="list-style-type: none"> <li>o The impact of climatic change on the environment</li> <li>o The impact of man-made activities on the environment</li> <li>o Finalizing and/or experimenting with environmental information systems and methodology for approaching the mechanisms of desertification</li> </ul> <p>3. Preparing decision and development support products:</p> <ul style="list-style-type: none"> <li>o Natural-resources management plan</li> <li>o Methods for rehabilitation and management of ecosystems</li> <li>o Environmental studies to support development projects</li> <li>o Desertification indicators</li> <li>o Biodiversity indicators</li> <li>o Thematic reports and maps</li> </ul> | <ul style="list-style-type: none"> <li>o Drawing up natural-resources maps using aerial photographs</li> <li>o Rehabilitating and restoring degraded ecosystems</li> <li>o Preparing thematic maps on land occupancy</li> <li>o Carrying out studies on hydrology and pedology</li> <li>o Assessing human impact on the environment</li> </ul> |

Figure 1: MAB and ROSELT-OSS network sites.



As an example, Tables 2 and 3 on pages 71 and 72 identify the activities conducted through the programmes in the Bou Hedma site in Tunisia and the El Omayed site in Egypt.

Developing synergy between the two programmes requires:

- Identifying the sites already belonging to both networks or which might join them in the future.
- Comparing files and dossiers presented within the framework of each programme.
- Assessing available results, current programmes, and the resources used at each site.
- Bolstering cooperation between the national teams responsible for managing both the MAB reserves and the ROSELT-OSS sites, in order to coordinate data collection and processing methods and thus facilitate diachronic studies of protected zones and buffer or transition zones.
- Ensuring the active participation of a UNESCO-MAB programme member on the ROSELT-OSS Scientific and Technical Committee, and vice-versa.
- Promoting joint UNESCO-MAB and ROSELT-OSS enlistment of financial means from bilateral and multi-lateral development cooperation partners.

## 5. Conclusions and Recommendations

There are many areas of convergence between the ROSELT-OSS programme and UNESCO -MAB, by way of their objectives (conservation, natural-resources management, sustainable development) and the activities intended to meet these objectives (ecological monitoring, studies of ecosystems, decision-making tools).

Suggestions being proposed for creating synergy between the two programmes include:

- An in-depth assessment of the complementarity of the two networks, incorporating joint activities, coordination of methods, validation and constructive use of data (study to be carried out by a consultant)
- Organization of an expert workshop to define a joint ROSELT-MAB programme. The workshop would be attended by national ROSELT and MAB representatives (from Tunisia, Morocco, Egypt, and Mali), ROSELT-OSS programme leaders (ES/OSS and regional operators), UNESCO-MAB leaders and resource managers. OSS and UNESCO could hold the meeting near the Bou Hedma reserve in Tunisia.
- Promoting the participation of national ROSELT-OSS teams in MAB network workshops and meetings, and vice versa.

# 15

## Land Degradation Assessment in Drylands

*Sally Bunning, Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome, Italy*

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### 1. Introduction

#### 1.1 DRYLANDS

Drylands cover a large part of the developed and the developing world. They are home to and provide for the livelihood of some two thousand million people. Drylands have low and highly variable rainfall, with major fluctuations from year to year and over periods of decades — pastoralists and farmers in the drylands try to maximise herd size and crop production during good periods and minimise losses to obtain adequate yield during periods of drought, and pastoralists may follow the seasonal variations in vegetation by moving their livestock, sometimes over large distances. Dryland systems, in which integrated grazing and crop management are often applied, are frequently quite resilient against year-to-year fluctuations in productivity, as they can bridge drought periods by drawing on local reserves, whether financial or in the form of fodder and food stocks.

#### 1.2 LAND DEGRADATION

Large areas in the drylands suffer from land degradation. The competition for moisture and nutrients for crop production results in the removal of the protective grass cover, with severe drought often leaving the soil highly vulnerable to wind erosion. Heavy grazing around watering points or during long drought periods prevents or delays regrowth of the vegetation, leaving only unpalatable shrubs. Wind erosion removes topsoil, while blown sand may damage crops or cover cropland. Heavy rain following a long dry period may seal the soil surface, cause runoff, and erode bare soil. Limited groundwater supplies may be exhausted or become saline through overuse or after long drought periods.

Many dryland areas have become more vulnerable to degradation because of an increase in the population during a more humid period, as was witnessed for example in the Sahel from the 1930s to the 1960s. Also, an increased use of water for irrigation, weakened community-based land-management institutions, and the expansion of

agricultural land into former dry-season grazing areas have all contributed to accentuating land degradation. In many dryland areas degradation, combined with periods of drought, has led to food insecurity, and in some cases to famine, epidemics, and emigration — often to overcrowded urban areas.

### 2. Why LADA?

In some places, dryland degradation has been reversed and communities have developed sound, sustainable approaches to land rehabilitation and management. However, not enough is known of the nature, extent, and severity of the different kinds of land degradation and their complex causes, both natural and human-made. Also, there is insufficient information on successful restoration in the drylands context, particular as regards policy and the institutions and socio-economic conditions under which specific approaches could be adapted and applied successfully.

Much information is available on a sectoral basis, but there is a need for tools and mechanisms to link the changes in land resources with socio-economic and human-management considerations, bringing an understanding of the dynamics of the ecosystem. Such knowledge is essential for communities and governments to take effective remedial action.

The main problems to be addressed by the Land Degradation Assessment in Drylands (LADA) project are:

- In many countries, especially in the developing world, reliable, comprehensive data is lacking or not suitably formatted for use in assessment models and procedures.
- Information from different national and international sources and at different scales cannot be readily identified, assessed and compared.

- There are no widely accepted indicators for the sustainable use and management of land resources and the goods and services they provide.
- In many countries inadequate attention is given to issues of land quality, ecosystem dynamics, gender differences, and the socio-economic, cultural, and political driving forces that promote or hinder effective responses to land degradation.
- An integrated, holistic approach linking socio-economic and institutional root causes with biophysical symptoms of land degradation at different temporal and spatial scales needs to be developed.

Countries participating in the United Nations Convention to Combat Desertification (UNCCD) have recognised that not enough is known of the causes, nature, extent, and severity of the different kinds of land degradation in drylands. They established a Global Mechanism to mobilise financial resources in support of national action programmes.

The Council of the Global Environment Facility (GEF) — an interagency partnership created to provide funding to developing countries and countries in transition to implement measures that provide global environmental benefits — recently designated land degradation as a focal area in order to enhance their support for the successful implementation of the UNCCD programme. The GEF has provided resources to catalyse the international partnership to support the LADA project in developing and testing an effective global assessment methodology for land degradation in the drylands.

LADA is putting together the pieces of a global challenge, by marshalling worldwide the extensive knowledge and varied expertise already available, by creating a new, more interactive and comprehensive framework of assessment methods, and by testing this framework in real-world situations. Once the tools and the data needed to understand the functioning of the degradation puzzle are assembled, it should be possible to identify the location of hotspots, determine the greatest land constraints and risks, and comprehend the reasons behind drought, floods, or degradation. Such information will assist communities and governments in the design of effective remedial measures and supportive policies.

## 2.1 WHO BENEFITS?

Farmer and pastoral communities will gain a clear understanding of the nature and risks of rapid or creeping degradation of their land, and will be in a position to test a range of options for land improvement and management, including those that have worked under similar conditions elsewhere, and adapt them to their local contexts.

Governments and their technical and scientific institutions will be assisted with methods of collection and

analysis of reliable and consistent, internationally comparable data on desertification and dryland degradation at national and local levels.

Governments will gain an overview of the distribution and intensity of different kinds of land degradation in their countries, and of their main contributing causes, enabling them to design or adapt policies, measures, and priority actions that will encourage and support land improvement and sustainable management by local communities. These may involve land-use legislation, land consolidation, capacity building at all levels, disaster crisis planning and facilitating transport and market access and other institutional and infrastructure aspects of the rural economy.

Such support, leading to the design and application of more appropriate dryland policies and strategic regulations, to more effective information dissemination, and to the development of mechanisms for participatory technology development should assist governments to stimulate the flow of well-targeted international investments for dryland restoration, conservation, and management.

## 2.2 A JOINT INTERNATIONAL EFFORT

The major national actors in LADA will be government institutions with responsibilities for the management of land resources, in particular the ministries in charge of land-use planning, agriculture, rural development, and the environment, as well as NGOs and other development agents concerned with these areas.

With funding from GEF and the Global Mechanism, and technical support from the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), and several other United Nations agencies, organizations are pooling their expertise to participate in this collective, system-wide task. They will work through partnerships with national and local governments and civil society organizations, and will concentrate on method development and testing, capacity building, data correlation, and information exchange and dissemination among all partners.

An International Steering Committee has been established, with membership drawn from the secretariats of the UN institutions concerned, including representation from countries, regional institutions, the donor community, the NGO community, research and development institutes, and organizations and technical experts.

## 2.3 THE LADA APPROACH

LADA follows a participatory, decentralized, country-driven approach and makes ample use of modern means of data gathering, processing, and communication for international cooperation and coordination.

Land degradation is a dynamic, interactive process that evolves and differs over time and space. Analysis of the responses to its impacts will be an important aspect of

LADA. Some degraded lands are relatively stable, others continue to deteriorate, while some may actually be on the way to recovery, often as a result of specific methods of land management. It is of the utmost importance for the control of land degradation to identify such trends and discover how and why they develop, so as to understand their specific driving forces: i.e. are they natural or a result of human interventions.

for local knowledge and modern science to be used in combination.

Assessment of the socio-economic driving forces and the cultural attributes and indicators linked to land degradation is crucial if reversing land degradation and generating win-win scenarios for mitigating threats of desertification, biodiversity loss, and climate change through promotion of sustainable land use are to be successful.

### **People's Participation**

The world's food producers, women and men, have a stake in the preservation of the environment and in environmentally sustainable development. Experience in combating dryland degradation has demonstrated that the full and equal participation of both women and men is essential for the success of sustainable development and the management of drylands. Land and water resources form the basis of all farming systems and their preservation is crucial to sustained and improved food production. As local people play an increasing role in preserving and managing their lands, the land will more likely meet their food security needs.

### **Local Knowledge**

Understanding and appreciating local knowledge of drylands preservation techniques and the social and cultural factors of local resource users is important. For this reason, environmental protection must be based on a solid understanding of women and men's relationships to dryland resources, of their respective rights, roles and concerns in resource planning and management, and of the gender-differentiated impacts of environmental degradation and misuse.

In view of the importance of driving forces and of changes occurring below the soil surface, assessment of land degradation cannot limit itself to a one-time survey of its most conspicuous impacts. It should also detect the less visible impacts and anticipate the less predictable ones: those that are below ground, which affect ecosystem functions and have off-site implications. This requires scientifically sound and reliable indicators, monitoring systems, and early warning systems, based on remote sensing and Geographic Information Systems (GIS) technology (particularly at the smaller scale). This has the effect of identifying resource quality and ecological processes, as well as related human interventions — the decision-making processes that underlie land use and management systems.

Recent advances in participatory assessment, planning, and management of resources provide an opportunity to develop a more reliable and innovative assessment methodology for land degradation, including its biophysical and socio-economic components, which allows

## **3. The LADA Project**

The two-year preliminary development phase of LADA was launched in 2002. This phase focuses on methodology assessment, development, and pilot testing; building a cooperative network of institutions; identifying and assessing sources of data with global and regional coverage; and preparation of the full-scale project.

Two consultations have been held to establish a network of partners and to structure the project. An international steering committee has been formed, and an assessment of the range of existing methods and data sources is underway.

### **3.1 OBJECTIVES**

LADA's main objectives are:

- The development and widespread application of a methodology to assess and quantify the nature, extent, severity, impact, and causes of land degradation in drylands, and the determination of remedial

### **Specific Land Management Methods For Different Environments**

Dryland agricultural and pastoral systems are risky, because the low and variable rainfall promotes severe hazards of drought — lasting weeks, months, or even several years. It is therefore essential to make optimal use of the rainfall, the water stored in the soil and any runoff, and where available, supplementary surface water or groundwater. Technologies to maximise rainwater retention and reduce losses while safeguarding the land from degradation are specific to different landscapes, soils and rainfall regimes, and dryland management methods

solutions. The assessment will integrate biophysical factors and socio-economic driving forces.

- To build national, regional and global assessment capacities that will enable the design and planning of interventions to mitigate land degradation and will provide incentives for and promote the adoption of sustainable land-use and management practices.

### 3.2 WORK PLAN

The two-year preparatory phase of methodology development and capacity building has been launched. New and integrated methods are to be tested in three pilot countries, and technical and financial contributions to this pilot process are being sought.

The subsequent four-year implementation phase of the LADA project will develop a network of information systems and a series of assessments of land degradation at national, regional, and global scales, focusing on areas at greatest risk ('hot spots') and areas where degradation has been successfully reversed ('bright spots').

The project will help countries build their national capacities for assessment and information management. It will provide an evaluation of best practices and related management and decision-making processes for the control and prevention of land degradation in drylands, together with the identification of effective remedial measures. It will continue work on the identification of suitable methods, procedures and tools based on modern technology, such as Geographic Information Systems (GIS), remote sensing, process modelling, and the use of Internet resources, which are applied to geo-referenced data for the monitoring of changes and the continual updating of knowledge and understanding of land degradation and remedial actions.

### 3.3 MAJOR OUTPUTS

- A standardized methodological framework that national institutions can use and apply effectively for the assessment of land degradation status, risks, and causes.
- A baseline map of dryland-degradation at the sub-regional scale, based on the collection and collation of existing maps and databases and the incorporation of new data and information where possible.
- Global assessment of actual dryland degradation and degradation hazards.
- A detailed assessment of land degradation at the national level, focusing on areas at greatest risk ('hot spots') and areas where degradation has been successfully reversed ('bright spots'), covering not only the state of degradation but its causes and impacts, together with identification of remedial measures.

- Analysis of land degradation areas at risk and their impact on the environment (ecosystems, carbon emissions, international waters, etc.) and on human livelihoods (food security, poverty, migrations, etc.).
- The elaboration of best practices for the control and prevention of land degradation in drylands, considering indigenous and traditional knowledge and information on indigenous practices.
- The communication and exchange of information on dryland degradation, and promotion of the use of such information in decision-making; through policy guidance, GEF interventions, priority actions, lessons learned and best practices, monitoring tools, etc.

### 3.4 IMPACTS

- A better understanding of the nature of interrelationships between technical, institutional, and policy factors in terms of land degradation.
- Reduced policy and institutional barriers to sustainable land use in dryland zones.
- Improved livelihoods, food security, and health for poor people in dryland areas, through better dryland-management practices.

## 4. Participating in LADA

Countries wishing to participate must designate a national focal point and establish a national co-operative network with the participation of ministries and other institutions concerned. They should register their participation with the LADA Secretariat.

Participating countries will be invited to join in regional workshops and international electronic consultations on the development of common methods, and to undertake their national assessment accordingly.

During the preparatory phase, countries and organizations wishing to launch pilot studies will test the methodology in one or more selected areas and report on their findings at international workshops. Other countries will prepare their participation for the full implementation phase of the project by taking stock of their experiences, compiling the information available from ministries and other institutions concerned, and building their national capacities to this effect.

The FAO will supply the national focal points with background material and data; guidelines and advisory services for capacity building; and linkages with its international geographic information systems and other databases, as well as providing specialized training, equipment and materials.

Interested institutions should seek participation in the LADA networks through its website or by contacting the LADA Secretariat.

# 16

## Information Management Within the Framework of ArabMAB

*Boshra B. Salem, Executive Director, ArabMAB network, Alexandria, Egypt*

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### 1. Introduction and the ArabMAB Declaration

Information needs for biodiversity are wide-ranging and various, and our state of knowledge is all too often unsatisfactory for proper evaluations to be made. It is generally recognized that there is an absence of reliable information about biodiversity at various scales, and consequently our understanding of biodiversity for the development of indicators and indices (which allow us to monitor and measure changes and trends over time) is limited.

The majority of countries have now signed the *Convention on Biological Diversity* (CBD). The convention explicitly recognizes that the conservation of biological diversity requires the development of strategies and action plans (Article 6), thus requiring the development of improved mechanisms for information collection and management (Article 7). Without adequate information it is difficult to develop effective strategies and action plans, and scant information on the implementation of these plans renders impossible the monitoring of such implementation as well as any necessary adjustments. Countries therefore are motivated to develop national information management strategies that incorporate information needs, sources, means of collection, information management and accessibility.

The notion of establishing an ArabMAB network was explored at the second regional meeting of Arab national committees, held in Cairo in 1994. A follow-up workshop for this purpose was held in Syria in 1996, where the objectives and institutional structure of the network were established. The network was launched in Amman in 1997. The Arab National Committees of the Man and Biosphere Programme (MAB) participating in the Third Meeting held in Amman, Jordan from 22–25 June 1997, stated in the “Amman Declaration” that they:

- *Recognized* guidance by the Arab declaration on Environment and Development as well as the recommendations of the Earth Summit held in Rio

de Janeiro (Brazil) in 1992 and the Seville Strategy on Biosphere Reserves in 1995;

- *Recognized* the need for cooperation in solving environmental problems in the Arab States;
- *Acknowledged* the need for strengthening and coordinating efforts to obtain healthy environments in the Arab region;
- *Decided* to launch the ArabMAB Network to:
- coordinate and enhance collaboration in various disciplines related to the MAB Programme;
- establish principles of a common Arab Programme, including the creation of biosphere reserves and other types of protected areas;
- assist member committees in adhering to relevant international conventions;
- undertake collaborative research projects and other activities according to proposals from member committees.

### 2. Objectives of the ArabMAB Network

The objectives of the ArabMAB Network were set out as follows:

- a. To coordinate and encourage cooperation between ArabMAB National Committees throughout various areas of the MAB Programme, and to strengthen the MAB Programme in the Arab region by establishing biosphere reserves.
- b. To coordinate and facilitate the regional activities of the MAB Programme. To fulfil this task the network will:
  - i) Collect proposals and collaborate with the UNESCO Cairo Office, the MAB Secretariat at UNESCO Headquarters, MAB National Committees in other countries and other MAB networks, as well as relevant Arab and international

organizations, to facilitate the implementation of these proposals;

- ii) Facilitate the implementation of applied research and study programs and assist in providing necessary consultation and funds;
- iii) Follow up implementation of the recommendations of the regional ArabMAB committees meetings;
- iv) Establish an environmental database in the Arab Region within the framework of the MAB Programme;
- v) Enhance cooperation and communication with other similar networks;
- vi) Publish studies, newsletters, and research results related to the MAB Programme in the Arab countries.

### 3. The ArabMAB Website

In order for this network to function effectively, an ArabMAB website was developed in 1998. It has since been continually revised to enhance the use of the network and incorporate regional biodiversity information.

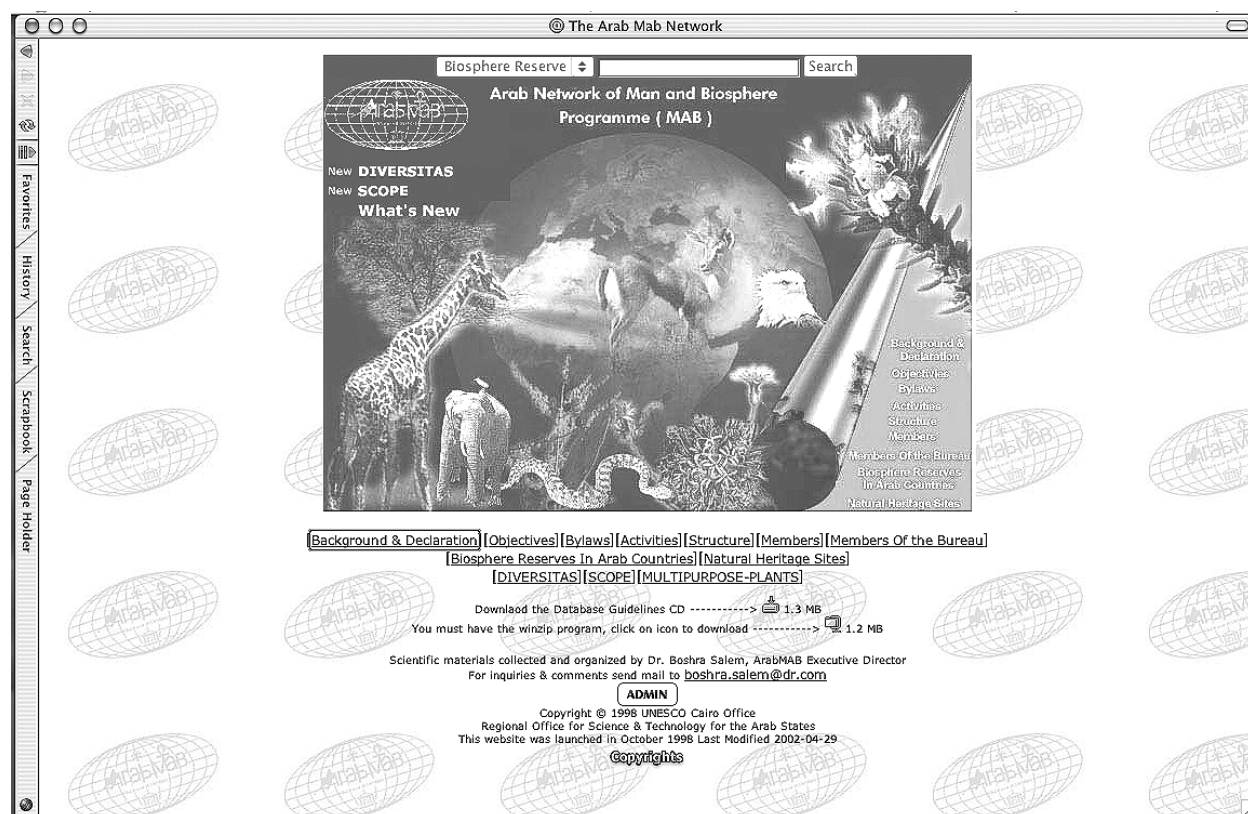
It was important to encourage the establishment of national biodiversity databases and metadata to facilitate information flows among networks for the purpose of data and information exchange. The ArabMAB network is an existing forum for biodiversity information, operating as a system of networks with twelve Arab member states participating as well as one member from an international organization.

The ArabMAB website's biodiversity database was created for use by Arab countries with existing biosphere reserves. In Arab member states there are currently fourteen biosphere reserves; in six countries, Algeria, Egypt, Jordan, Morocco, Sudan and Tunisia. The ArabMAB biodiversity database incorporates a search engine that identifies information according to flora or fauna or according to the country. The website was constructed to include a "front-end" site available to the wider public and a "back-end" site accessible only to biosphere reserve managers responsible for administering their databases. Access is by login name and password.

#### 3.1 TECHNOLOGICAL CHANGES:

Launched in 1998, the website's database was initially structured and operated using a Microsoft Access database, however, Access eventually proved unstable and inadequate at high loads. Microsoft's more robust SQL Server is now used to manage the database, overcoming earlier problems.

The application server used previously was Microsoft's Visual Basic, which automatically generated executable (.exe) files that interrogated the database, giving the results in hypertext (HTML). This program has been replaced by Allaire's Cold Fusion, which generates ".cfm" files to interrogate the database and retrieve the requested content. Cold Fusion is a more reliable and rapid program that allows the database design to be easily altered.



### 3.2 FEATURE CHANGES:

Previously, the interface design of the site could not be altered, because the technology used, Visual Basic, automatically generated the final HTML page without any administrative interference. With the technology changes cited above, feature changes to the site can now be easily performed administratively, where three levels of control are currently possible. They are as follows:

*Full Front-End Control Level:* this enables full technical administration by the technical webmasters in the event of upgrading requests by the website host. The technical webmasters can change any feature in the ArabMAB website — e.g. the interface design, user screens, or database structure and design.

*Administrative Back-End Control Level:* this enables the webmaster and UNESCO Headquarters to make changes to the database content for all biosphere reserves. For example, biosphere reserve can be added or removed, or flora or fauna species common to two or more biosphere reserves can be added or deleted. However the interface design of the site cannot be altered.

*Per User Back-End Control Level:* This enables authorized users — for example, individuals nominated as responsible for administering the database for any particular biosphere reserve — to make changes to the database of their corresponding reserves only. These individuals log in with a username and a password to identify themselves. Once they have logged in, they can make alterations to the database content through user-friendly

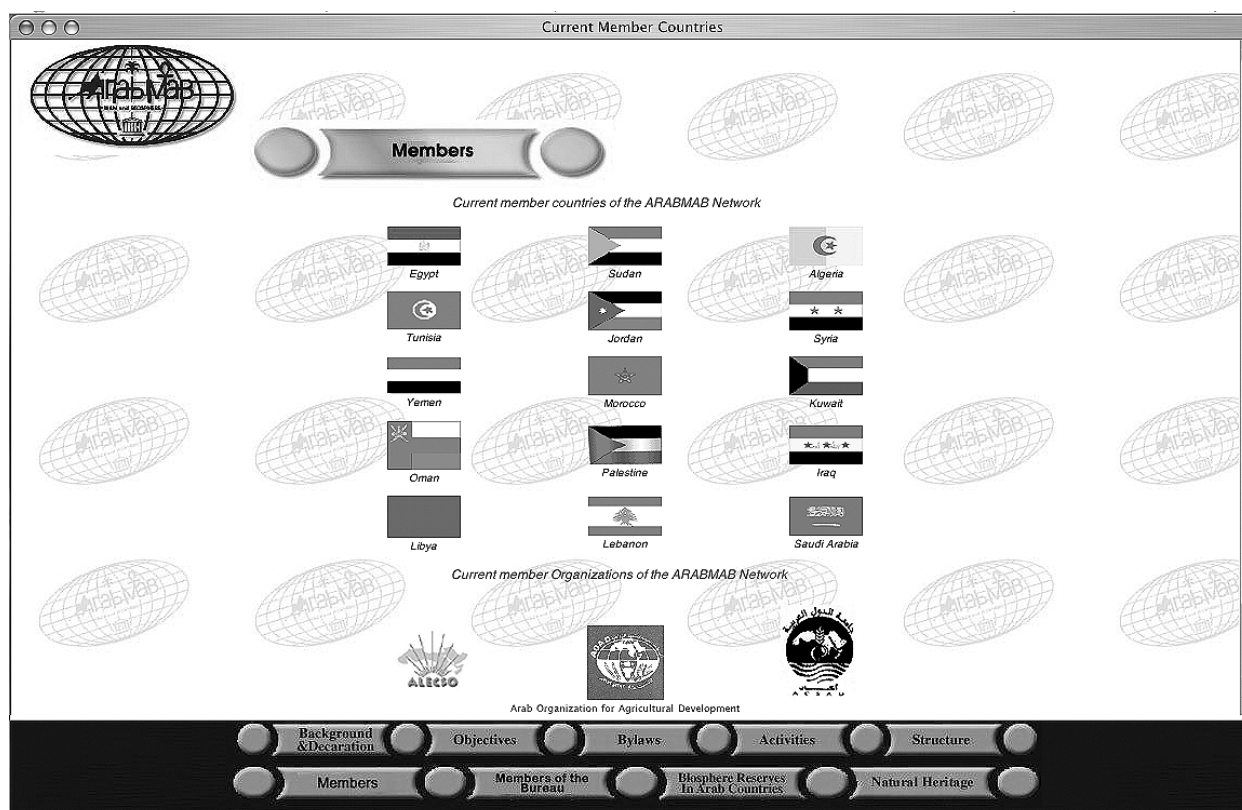
interface screens, tailored to suit the data types used in the ArabMAB database. However, such users cannot alter the interface design of the site.

### 3.3 ARABMAB ADMINISTRATION

The ArabMAB website is addressed, within the UNESCO framework, primarily towards reinforcing the MAB regional network and promoting the online Arab biodiversity database (which is incorporated into the website). We have also produced a guideline booklet and a tutorial CD to help members of ArabMAB and other users of the ArabMAB biodiversity database to understand the structure of this electronic database and to enhance their capabilities in administering the database online. The CD and the booklet share the same design and were distributed to biosphere reserve managers in nationally nominated Arab countries.

The front page of the CD depicts the UNESCO, MAB and ArabMAB logos. This page contains links to the disk's content, in Arabic and English. These links lead to the main menu of the CD, which includes the following items:

1. "What is the ArabMAB Network?": a brief introduction to ArabMAB, its objectives and activities.
2. "What is the Database and Why?": discusses the meaning behind the database concept,
3. "Biodiversity Database on the ArabMAB Website": a description of recent upgrades to the ArabMAB website, in terms of both features and technological changes,



4. "Structure of the Database on the ArabMAB Website": a description of the website's database, explaining the back-end program and the levels of database administration security,
5. "Database Administration on the ArabMAB Website: How To?": explains the process of online database administration,
6. "Help on Error Messages": explains error messages that may appear during database administration,
7. "What is?": a glossary of terms used.

As mentioned above, the CD's content is repeated in English and Arabic. The main menu links are shown below; each leads to sublinks to pages describing that step of the process, using simulated screens from the site's back-end program. The CD trains users to work with these screens productively to perform required tasks.

For example, Item 5, which covers the bulk of the CD, takes you to the following sublinks:

- Login
- Main Menu Screen
- Updating Biosphere Reserves
- Updating Flora/Fauna Data
- Updating Data on Members of the ArabMAB Bureau
- Inserting Events
- Adding Member Countries to the Network
- Changing Passwords
- Logout

Each of these sublinks takes the user to replicas of screens used on the website to add new data, remove old data, or to update existing data. These screens are hyperlinked so that the user can navigate through them to understand the sequence of steps he/she will have to follow on the website. Users are provided with descriptions of the steps to follow, the buttons to click, and the results of each action. If a digital photo is to be entered into the database, the appropriate format, size, and resolution are explained. Dialogue boxes and explanations of warnings and error messages are also provided wherever appropriate.

The CD includes auto-run or executable files that launch it automatically once it is inserted into the CD drive. A copy of the CD's content is available for downloading on the home page of the ArabMAB website ([www.arabmab.net](http://www.arabmab.net)).

The CD-ROM is a successful initiative that presents in both a logical and pedagogical manner the ArabMAB website's database structure and its levels of security, while providing information on database-administration procedures, including information about data formats and how data should be added, edited, and deleted from the database. It serves as a tool to enable participants from Arab countries and members of the ArabMAB network responsible for pages of the ArabMAB website to administer their own biodiversity data from biosphere reserves, and illustrates the use of network technology and communication to promote the ArabMAB network.



## 4. Conclusion

ArabMAB represents a successful network that disseminates and transfers information and experience via the highest level of communication technology. This effective tool is indispensable for establishing new biosphere

reserves in Arab countries and strengthening the existing ones, indispensable for conserving our biodiversity and maintaining a comprehensive and functional electronic biodiversity database of Arab Biosphere reserves.

Arab Mab

**Addax nasomaculatus**

Common Name : Addax  
BR Name : Tassili N'ajjer -Algeria  
BR Name : Djebel Soudhema-Tunisia



| Class   |       |          |            | Conservation Value |            |  | Invasive |
|---------|-------|----------|------------|--------------------|------------|--|----------|
| Mammals | Birds | Reptiles | Amphibians | Endemic            | Endangered |  |          |
| yes     | -     | -        | -          | -                  | yes        |  |          |

[\[Notion & Declaration\]](#) [\[Objectives\]](#) [\[Bylaws\]](#) [\[Activities\]](#)  
[\[Structure\]](#) [\[CurrentMember Countries\]](#) [\[Members Of the Bureau\]](#)  
[\[Biosphere Reserves In Arab Countries\]](#) [\[Home\]](#)

[Background & Declaration](#) [Objectives](#) [Bylaws](#) [Activities](#) [Structure](#)  
[Members](#) [Members of the Bureau](#) [Biosphere Reserves In Arab Countries](#) [Natural Heritage](#)

Arab Mab

**Thymelea hirsutae**

Common Name : Mithnaa  
BR Name : Omaied Biosphere Reserve (OBR)-Egypt



| Habitat                  | Life Form |       |      | Properties                    | Conservation values |            | Importance                            |         |             |                                  | Invasive |
|--------------------------|-----------|-------|------|-------------------------------|---------------------|------------|---------------------------------------|---------|-------------|----------------------------------|----------|
|                          | Tree      | Shrub | Herb |                               | Endemic             | Endangered | Economic                              | Grazing | Nutritional | Medical                          |          |
| coastal calcareous dunes | -         | yes   | -    | Xerophytic Steppic Vegetation | -                   | -          | fuel-wood<br>ropes<br>roofs<br>fences | -       | -           | Respiratory system (expectorant) |          |

[Background & Declaration](#) [Objectives](#) [Bylaws](#) [Activities](#) [Structure](#)  
[Members](#) [Members of the Bureau](#) [Biosphere Reserves In Arab Countries](#) [Natural Heritage](#)

# Final Report and Conclusions

1. **T**he International Workshop on Desertification: Rehabilitation of Degraded Drylands and Biosphere Reserves took place in Aleppo (Syrian Arab Republic) on May 2 and 3, 2002. The workshop was organized by UNESCO's Man and the Biosphere Programme (UNESCO-MAB) in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) and the United Nations University (UNU). The workshop was held at ICARDA's headquarters and included a visit to ICARDA's research laboratories and experimentation/demonstration farms at Tel-Hadya.
2. Fourteen participants invited by UNESCO-MAB from the following countries attended the workshop: Egypt, Germany, India, Japan, Jordan, Lebanon, Morocco, Pakistan, the Russian Federation, Sudan, Tunisia, and Yemen. Representatives of the following United Nations agencies and programmes and other international organizations also took part in the workshop: the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations University (UNU), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Sahara-Sahel Observatory (*Observatoire du Sahara et du Sahel*, or OSS). ICARDA's Board of Trustees attended the workshop's opening session. About twenty participants from ICARDA's research staff also attended the workshop. The list of participants and the workshop agenda are provided with these proceedings.
3. According to the workshop's theme, a series of case studies on the rehabilitation of degraded drylands was presented. The majority focused on site-specific examples of biosphere reserves. Representatives of international organizations provided overviews of the work of their organizations in the fields of dryland rehabilitation, combating desertification, environmental monitoring, and regional and global networking.
4. The workshop addressed in particular the following questions:
  - i. Can core areas of biosphere reserves and protected areas of similarly managed sites be considered as "reference sites" for assessing potential natural vegetation and viable wildlife populations in drylands?
  - ii. Can the gene pools contained in the core areas of biosphere reserves be used for restoration measures carried out in the buffer and transition zones?
  - iii. Which cash crops and multi-purpose species have proven to be particularly successful in fostering both rehabilitation of degraded drylands and income-generation for local people dwelling in the transition zones of biosphere reserves?
  - iv. Can traditional knowledge help to combat desertification?
  - v. Can suitable test sites (biosphere reserves and similarly managed areas) in Africa, Arab States, and Asia be identified for a joint research initiative on the rehabilitation of degraded drylands?

5. IN RESPONSE TO THE FIRST QUESTION, several participants argued that core areas of biosphere reserves can indeed be considered as reference sites for the potential natural vegetation of drylands, particularly as they are relatively well conserved *vis-à-vis* the more human-impacted and degraded surrounding areas. Other participants, however, felt that only a case-by-case approach could provide the right answer to this question, as core areas may have been nominated for a specific conservation value they possess and may not necessarily be representative of a typical dryland ecosystem (examples include the occurrence of endemic species, such as in the Arganeraie Biosphere Reserve in Morocco; of gene pools of wild relatives of domesticated species; or of rich biodiversity and rare or threatened species because of abundant water resources in an otherwise water-deficient environment). In essence, it was felt that core areas should be considered as reference sites, particularly if a biosphere reserve was sufficiently large to encompass an entire range of areas of significant conservation value and to include areas that contribute to the economic well-being of the local population, in line with conservation objectives. As some of the first-generation biosphere reserves are limited in size, the question of the scale of a biosphere reserve becomes essential in determining whether its core area can be used as a reference site.
6. WHEN CONSIDERING THE SECOND QUESTION, it is important to determine the overall management and land-use objectives of each biosphere reserve. Buffer zones can either be used for restoration ecology — drawing on the gene pool of the core area(s) and serving to expand the biosphere reserve's core area(s) — or for rehabilitation activities (similarly to transition zones), enhancing the agro-biodiversity of a given area and generating income for dryland dwellers. For each biosphere reserve, special attention has to be given to the rationale behind its initial nomination. In essence, restoration activities in buffer zones should be carried out in line with plant associations and species compositions found in the core areas. Within this context, it was noted that the spatial pattern of biosphere reserves in dryland ecosystems is essentially determined by water availability: the critical factor for both the designation of conservation areas and the designation of areas for economic purposes (such as agriculture or pastoralism). It was therefore suggested that the zonation of biosphere reserves in dryland ecosystems must be determined according to watersheds and precipitation zones; noting that precipitation zones may correspond to geomorphological units, such as mountains functioning as water-catchment areas.
7. SEVERAL SUCCESSFUL CASH CROPS AND MULTI-PURPOSE SPECIES were mentioned in the context of dryland rehabilitation during the case-study presentations (i.e. xerophytes and halophytes such as jojoba, acacia, prosopis, tamarix, and zizyphus species). While some participants highlighted the merits of the introduction of exotic multi-purpose species in dryland areas, others cautioned against introducing exotic species, pointing out that they may be invasive and become dominant, thus jeopardizing the original ecological balance of the ecosystem. It was felt that, in the field of dryland rehabilitation, emphasis should be placed on the propagation and use of local and indigenous multi-purpose species, as there is often also a wealth of accessible traditional knowledge among local people on their specific uses. The example of the Aral Sea, demonstrating the varied and different stages of the natural succession of vegetation for the rehabilitation of drylands, needs to be studied further.
8. ON THE QUESTION OF TRADITIONAL KNOWLEDGE, participants were of the opinion that local and indigenous knowledge indeed provides an important means to combat desertification, as it is often based on simple and “affordable” (inexpensive) technology. The plethora of traditional knowledge available extends from knowledge of pollinator and medicinal species through to the use of certain species for pest control. Such knowledge can prove to be a very effective tool in ensuring survival under harsh dryland conditions. Several participants felt that traditional knowledge ought to be documented to prevent its loss or disappearance. Participants agreed that traditional knowledge needs to be tested and validated by scientific research, and that in some cases traditional knowledge to combat desertification should be complemented with modern technology.
9. WHEN CONSIDERING THE FIFTH QUESTION, participants felt that biosphere reserves (and similarly managed areas) should be identified as testing sites in Africa, the Arab States, and Asia, to carry out studies on the rehabilitation of degraded drylands. The structure of the World Network of Biosphere Reserves allows for the facilitation of information exchanges among scientists and decision-makers both within and between countries. Several biosphere reserves, in particular in the dryland areas of Egypt, Jordan, Morocco, Pakistan

and Tunisia, would be good candidate sites for a comparative study project on dryland rehabilitation and the sustainable management of marginal drylands that UNESCO, UNU and ICARDA are in the process of elaborating.

10. Finally, all of the workshop participants expressed the wish to continue working together through similar workshops on the theme of dryland degradation and rehabilitation in the context of biosphere reserves. It was appreciably noted that this workshop succeeded in promoting information exchange across many regions, from northern Africa to the Arab States and through to southern and central Asia. Participants concluded that future workshops on drylands and biosphere reserves should endeavour to elaborate common methodologies and to standardize data collection for comparative studies, considered important in the overall field of dryland rehabilitation. Participants agreed that a UNESCO-MAB workshop should be organized on the topic of traditional knowledge and modern ecology to combat land degradation and desertification in drylands, which could be held in the Republic of Kalmykia (Russian Federation) in early 2003. Representatives of international organizations, in particular ICARDA, UNEP, UNU, FAO, and OSS, signalled their interest in participating and eventually providing support for future workshops of this kind. The OSS's Long-Term Ecological Monitoring Network, ROSELT (*Réseau d'Observatoires de Surveillance Ecologique à Long Terme*) could provide important methodological guidelines for the monitoring of flora and fauna in drylands.

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11. The workshop was closed in very positive spirit, especially with regards to future joint collaboration among participants. UNESCO-MAB, as the principal organizer of the workshop and on behalf of all participants, thanked ICARDA for their excellent and outstanding logistic support provided. As this workshop also coincided with the twenty-fifth anniversary of ICARDA, workshop participants wished to express their gratitude to ICARDA for the invitation to take part in ICARDA's festivities organized for the occasion. UNESCO-MAB, ICARDA and UNU look forward to continued collaboration on dryland issues.

# INTERNATIONAL WORKSHOP ON DESERTIFICATION: REHABILITATION OF DEGRADED DRYLANDS AND BIOSPHERE RESERVES

ICARDA, Aleppo, Syria — 2<sup>nd</sup> and 3<sup>rd</sup> May 2002

## Workshop Agenda

Thursday, 2<sup>nd</sup> May 2002

### **Morning Session:**

**8:30–10:00 am**

#### **Opening Session**

Chairperson: Prof. Iwao Kobori, United Nations University (UNU)

- Prof. Mohamed El Deek: Opening of workshop on behalf of UNESCO;
- Prof. El-Beltagy: Opening of workshop on behalf of ICARDA and focus on ICARDA's experience in the rehabilitation of degraded drylands in Central and Western Asia and Northern Africa;
- Dr. Thomas Schaaf: UNESCO-MAB and the World Network of Biosphere Reserves — conservation and rehabilitation using the biosphere-reserve concept.

*10:00–10:30 am*

*Coffee break*

**10:30 am–1:00 pm**

#### **Thematic Session: Principles of Dryland Restoration/Rehabilitation in Biosphere Reserves**

Chairperson: Prof. Saeed Ba-Angood, Yemen

*Case Studies:*

- Prof. Iwao Kobori, Approaches for Integration of Land-Management Practices — UNU's Experience in Networking and Capacity Development
- Prof. Kamal H. Shaltout — Omayed Biosphere Reserve, Egypt
- Dr Driss El Fassi — South Moroccan and Arganeraie Biosphere Reserves, Morocco
- Prof. Hassan Abdel Rahman Musnad — Dinder Biosphere Reserve, Sudan
- Dr Ali Nefzaoui — Djebel Bou-Hedma Biosphere Reserve, Tunisia

*1:00–2:00 pm*

*Lunch*

### **Afternoon Session:**

**2:30–4:30 pm**

#### **Thematic Session: Principles of Dryland Restoration/Rehabilitation in Biosphere Reserves**

Chairperson: Prof. Driss Fassi, Morocco

*Case Studies:*

- Dr R.K. Rai — Dryland Biosphere Reserves in India
- Prof. Ahmad El-Oqlah, UNESCO Chair on Desertification at Yarmouk University (Jordan) — Forest Plant Biodiversity in Jordan
- Prof. Siegmund Breckle: Rehabilitation of the Aral Sea Environment, Kazakhstan
- Mr Muhammad Akram — Rehabilitation of Degraded Drylands in Dingarh, Cholistan Desert, Pakistan

*7:45 pm*

*Bus to the old town*

**8:00–10:00 pm**

**Dinner Reception in old town of Aleppo**

Friday, 3<sup>rd</sup> May 2002

8:30–9:30 am      **Visit to ICARDA's research laboratories and demonstration/training farm**

**Morning Session:**

9:30–10:30 am      **Thematic Session: Principles of Dryland Restoration/Rehabilitation in Biosphere Reserves**

Chairperson: Dr Boshra Salem, Egypt

- Dr Valery Neronov — Chernyje Zemli Biosphere Reserve, Russian Republic of Kalmykia
- Dr Mariam Akhtar-Schuster — Desertification in Namibia: Methodological Approaches of the BIOTA Southern Africa project

10:30–10:45 am      *Coffee break*

10:45 am–1:00 pm      **Thematic Session: Networking, Information Exchange, and Databases**

- Dr Al Assiri – Preparation and Implementation of the Sub-Regional Action Programmes (SRAP) to Combat Desertification in West Asia ;
- Ms Wafa Essahli: Environmental Monitoring and Information Exchange within the Framework of the Sahara-Sahel Observatory (OSS)
- Ms Sally Bunning, FAO: Land Degradation Assessment in Drylands (LADA);
- Dr Boshra Salem: Information Management within the Framework of ArabMAB.

1:00–2:00 pm      *Lunch*

**Afternoon Session:**

2:00–3:30 pm      **Workshop Session**

Chairperson: Dr Thomas Schaaf, UNESCO

*Discussion and conclusions, with recommendations for future collaborative work*

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## List of Acronyms

|         |                                                                                                                                                           |         |                                                                                                                           |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------|
| ACSAD   | Arab Center for the Study of Arid Zones and Drylands                                                                                                      | GM      | Global Mechanism                                                                                                          |
| ArabMAB | Arab Network of UNESCO's Man and the Biosphere Programme                                                                                                  | ICARDA  | International Centre for Agricultural Research in the Dry Areas                                                           |
| BMBF    | German Federal Ministry for Education and Research ( <i>Bundesministerium für Bildung und Forschung</i> )                                                 | ICRISAT | International Crops Research Institute for the Semi-Arid Tropics                                                          |
| CAMRE   | Council of Arab Ministers Responsible for the Environment                                                                                                 | ICSU    | International Council of Scientific Unions                                                                                |
| CBD     | Convention on Biological Diversity                                                                                                                        | IDRC    | International Development Research Centre                                                                                 |
| CEDARE  | Centre for Environment and Development for the Arab Region and Europe                                                                                     | IFAD    | International Fund for Agricultural Development                                                                           |
| CGIAR   | Consultative Group on International Agricultural Research                                                                                                 | INRAT   | National Institute of Agronomical Research in Tunisia ( <i>Institut National de la Recherche Agronomique de Tunisie</i> ) |
| CILSS   | Permanent Inter-State Committee for Drought Control in the Sahel ( <i>Comité permanent Inter-états pour la Lutte contre la Sécheresse dans la Sahel</i> ) | IPAL    | Integrated Project on Arid Lands                                                                                          |
| CIPSEG  | Cooperative Integrated Project on Savannah Ecosystems in Ghana                                                                                            | IPGRI   | International Plant Genetic Resources Institute                                                                           |
| CWANA   | Central and West Asian and North African                                                                                                                  | IRA     | Institute of Arid Regions ( <i>Institut des Régions Arides</i> )                                                          |
| EEAA    | Egyptian Environmental Affairs Agency                                                                                                                     | IUCN    | World Conservation Union (formerly the International Union for the Conservation of Nature)                                |
| EPA     | Environmental Protection Agency                                                                                                                           | KALRES  | Kenya Arid Lands Research Station                                                                                         |
| FAO     | Food and Agriculture Organization of the United Nations                                                                                                   | LADA    | Land Degradation Assessment in Drylands                                                                                   |
| FAPIS   | Training and Education in Integrated Pastoral Management in the Sahel ( <i>Formation en Aménagement Pastoral Intégré au Sahel</i> )                       | MAB     | or UNESCO-MAB. UNESCO's Man and the Biosphere Programme                                                                   |
| GCC     | Gulf Cooperation Council                                                                                                                                  | NAP     | National Action Programmes                                                                                                |
| GEF     | Global Environment Facility                                                                                                                               | NARS    | National Agricultural Research Systems                                                                                    |
| GIS     | Geographic Information Systems                                                                                                                            | NGO     | Non-Governmental Organization                                                                                             |
|         |                                                                                                                                                           | OPEC    | Organization of Petroleum Exporting Countries                                                                             |
|         |                                                                                                                                                           | OSS     | Sahara-Sahel Observatory ( <i>Observatoire du Sahara et du Sahel</i> )                                                    |

|         |                                                                                                                                                                                                |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PCRWR   | Pakistan Council of Research in Water Resources                                                                                                                                                |
| RAP     | Regional Action Programme                                                                                                                                                                      |
| REMDENE | Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt                                                                                                         |
| ROSELT  | or ROSELT-OSS. The OSS's Long-Term Ecological Observatories Monitoring Network ( <i>Réseau d'Observatoires de Surveillance Ecologique à Long Terme du Observatoire du Sahara et du Sahel</i> ) |
| ROWA    | or IUCN-ROWA. The IUCN's Regional Office for West Africa                                                                                                                                       |
| SAMDENE | Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt                                                                                                                          |
| SRAP    | Sub-Regional Action Programme                                                                                                                                                                  |
| TREMU   | Turkana Resources and Evaluation Monitoring Unit                                                                                                                                               |
| UNCCD   | United Nations Convention to Combat Desertification                                                                                                                                            |
| UNCED   | United Nations Conference on the Environment and Sustainable Development                                                                                                                       |
| UNDP    | United Nations Development Programme                                                                                                                                                           |
| UNEP    | United Nations Environment Programme                                                                                                                                                           |
| UNESCO  | United Nations Educational, Scientific and Cultural Organization                                                                                                                               |
| UNU     | United Nations University                                                                                                                                                                      |
| WANA    | West Asian and North African                                                                                                                                                                   |

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