

The Global Drylands Partnership
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**BIODIVERSITY IN DRYLANDS:
CHALLENGES AND OPPORTUNITIES FOR
CONSERVATION AND SUSTAINABLE USE**

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EXECUTIVE SUMMARY

Dryland species and ecosystems have developed unique strategies to cope with low and sporadic rainfall. They are highly resilient and recover quickly from prevailing disturbances such as fires, herbivore pressure and drought. These attributes have great significance for the global system, especially in the context of climate change. Dryland people have engineered pastoral and farming systems, which are adapted to these conditions and have sustained the livelihoods of dryland people for centuries.

This paper presents a review of the status and trends of dryland biodiversity and explores options for its conservation and sustainable use. Findings of the review can be summarized as follows: (i) agrobiodiversity is relatively well preserved; dryland farmers maintain high levels of biodiversity of crops and livestock breeds in their farms and family herds; (ii) the status of wild animal and plant species diversity is poorly documented, apart from IUCN Red Lists records on endangered species ; (iii) the immediate major threat to dryland biodiversity appears to be the degradation of ecosystems and habitats caused by new and powerful forces of environmental degradation : urbanization and other forms of human settlements, commercial ranching and monocultures, industrialization, mining operations, widescale irrigation of agricultural land, poverty-induced overexploitation of natural resources, and underlying them all, disincentives and distortions in the enabling environment. These new forms of disturbances often overpower the legendary resilience of dryland ecosystems and constitute potentially serious threats to dryland biodiversity. Wetlands, oases and groves, all of which are « micro hot spots » of dryland biodiversity, appear to be particularly vulnerable. Iterative and complex interactions between desertification, climate change and biodiversity underline the significance of drylands for the global environment.

Priority areas that require urgent action have been identified to increase awareness about the potentials of drylands and about the importance of dryland biodiversity.

1. INTRODUCTION

Drylands have an immense scientific, economic and social value. They are the habitat and source of livelihood for about one quarter of the earth's population. It is estimated that these ecosystems cover one third of the earth total land surface and about half of this area is in economically productive use as range- or agricultural land (CCD Secretariat, 1997).

Dryland ecosystems contain a variety of native animal, plant and microbial species that have developed special strategies to cope with the low and sporadic rainfall, and extreme variability in temperatures that prevail in these ecosystems. Such adaptive traits have global importance, especially in the context of predicted climate change.

Dryland pastoralists and farmers have developed efficient pastoral and mixed cropping systems adapted to the difficult conditions of drylands. These systems have sustained the livelihoods of generations of dryland people. Furthermore, dryland pastoralists and farmers have successfully created and maintained high levels of agrobiodiversity of crops and livestock breeds. Yet, global awareness about the great value of drylands remains frustratingly low. Compared to tropical rain forests, for example, the wealth of dryland biodiversity and indigenous knowledge is less well documented, and has received much less support and advocacy in conservation media.

Although remnants of healthy dryland biodiversity and indigenous knowledge still exist at various locations, drylands face increasing threats of further degradation. Already, as sources quoted by SBSTTA (1999) report, it is estimated that 60 percent of drylands is already degraded resulting in an estimated annual economic loss of USD 42 billion world-wide. Thus, continued degradation of drylands is a major threat to the ecological functions of drylands and to the species and genes living in these ecosystems and thus to human welfare.

Drylands need urgent attention. Efforts in the past to address dryland issues have achieved much less than expected. Thus new paradigms are needed to go beyond the status quo with imagination and courage. The purpose of this paper is to (i) draw greater attention to the potentials of drylands and (ii) suggest options for better conservation and sustainable use of dryland biodiversity.

2. DEFINITION AND EXTENT OF DRYLANDS

The term *drylands* is used in this paper to cover hyper-arid, arid, semi-arid and dry subhumid ecosystems. Aridity zones as widely used in the scientific literature are based on the ratio P/PET (where P is the area's mean annual precipitation and PET is the mean potential evapotranspiration). This ratio is referred to as aridity index and is used to classify drylands as hyper-arid (ratio less than 0.05), arid (0.05 to 0.20), semi-arid (0.20 to 0.50) and dry subhumid areas (0.50 to 0.65).

Drylands as defined above are equivalent to what the CBD's Subsidiary Body for Scientific, Technical and Technological Advice refers to as "drylands, arid, semi-arid, savannah, and grassland and Mediterranean ecosystems" (SBSTTA, 1999). Dryland ecosystems cover extensive land areas stretching across more than one third of the earth's land surface. They are found on all continents in both the northern and southern hemispheres, and are home to about one quarter of the earth's population. They cover a variety of terrestrial biomes which are

extremely heterogeneous with wide variations in topography, climatic, geological and biological conditions. The main dryland ecosystem-types have been described in some details including geographic distribution, land area, vegetation type and various aspects of biodiversity (PIED 1995 ; SBSTTA 1999).

Despite differences between various dryland ecosystem-types caused by differences in levels of aridity, topographic elevation, geological and biological conditions, etc., these ecosystems have in common a unifying characteristic: precipitation is low and extremely variable. Recurrent droughts that may persist for several consecutive years are the rule, not the exception. Furthermore, and particularly in the more arid areas, diurnal temperature variability is high, thus required special adaptations from all species.

3. DRYLAND BIODIVERSITY STATUS AND TRENDS

The United Nations Convention on Biological Diversity defines *biological diversity* as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". This section reviews the status of dryland biodiversity and assesses its future trends.

3.1- Driving Forces of Biodiversification in Drylands

As indicated earlier, dryland ecosystems cover a variety of terrestrial biomes (i.e. arid steppe, grasslands at various altitudes and latitudes; tropical and sub-tropical savannahs; dry forest ecosystems and coastal areas) which are extremely heterogeneous. A major driving force of biological diversification in dryland environment is relative aridity. Within each aridity zone, significant variations between sites are introduced by topography and geology as mentioned earlier, and also by variations in the most limiting factors - i.e. water and soil nutrients. The resulting patchwork of habitats determines the distribution of living organisms.

In addition to habitat differentiation, other driving forces of biodiversification in drylands include the seasonal pattern of rainfall, fires and herbivore pressure. Types and intensities of these environmental stresses combine to determine the main selection pressures in drylands: low and highly variable rainfall in time and space; recurrent but unpredictable droughts that may persist for several consecutive years; high temperatures; inherently low soil fertility; high incidence of salinity; prevailing herbivore pressure; and fires. These stresses have selected for a large diversity of adaptive traits.

The seasonal pattern of rainfall, for example, has selected for plant and animal species and micro-organisms able to develop rapidly and complete their life cycle in a very short period of time. Adaptation to drought has selected for a wide range of strategies as shown in Box1. Some species have mechanisms to escape drought whereas other species have appropriate organs to resist drought. Plant species, for example, have large below ground systems to store water and nutrient or corky bark to insulate living cells from desiccation and fire burning (Medina *et al.*, 1992; SBSTTA, 1999).

Box 1: Biological adaptation to drought in drylands

(Sources: SBSTTA, 1999)

- Drought escapers (i.e. - plants "escaping" into seeds, or insects "escaping" into the egg or larval stage until wet weather returns;
- Drought evaders (i.e. - plants such as the salt bush with efficient, deep and widespread root systems or animals such as snakes and lizards that avoid the heat burying themselves underground;
- Drought resistors (i.e. - cacti that store the water in roots and trunks, or camels that minimise water loss);
- Drought endurers (i.e. - shrubs and trees that go dormant, or animals such as frogs that estivate during dry seasons.

Another powerful selection agent is human population. Local people have developed complex pastoral and cropping systems for which they have selected and maintained the biological diversity they value most in domestic livestock and crops.

3.2- Status of Dryland Biodiversity

Dryland ecosystems are unique. One can cite such examples as the Mediterranean systems (e.g. the distinctive sclerophyllous vegetation of the Mediterranean Basin, drylands of Southern Australia and California, Chile, Cape Floral Kingdom of South Africa, and shrublands of Australia); the cold deserts of Mongolia and Chile; the Sahara and Sahel of Africa; the arctic circle drylands; and the high altitude drylands of Iran and Afghanistan; just to name a few.

Total number of named species in the world is approximately 1.4 million or more (Arroyo *et al* 1991). How many are from drylands, however, is not well documented. Furthermore, the degree of threat and extinction is not well known. Specifically, it is not possible to ascertain the correlation between the rate of degradation of drylands (estimated as 60%) and the rate of extinction of species because of the lack of data on endemic species distribution.

In a very challenging paper titled "*There is more to biodiversity than the tropical rainforests*", Readford *et al* (1990) pointed out that much of the publicity concerning threats to global ecosystems and biodiversity has centered on tropical rainforests. While the authors concede that there is no doubt of the importance of moist tropical forests in terms of biodiversity, they also voiced concern that the almost exclusive attention to rainforests may act as blinders, limiting the vision of major conservation stakeholders: donor agencies, governmental bodies, etc. This would in turn lead to the neglect of other ecosystems. One such neglected ecosystem is the world dryland.

The sub-group on biodiversity of the CBD's international panel of experts also noted that the scientific community and international agencies that spearheaded efforts to raise awareness about rainforest biodiversity are conspicuously absent from the dryland debate (PIED, 1995). Low awareness about the importance of drylands vis-à-vis biodiversity and livelihoods is one of the reasons why this ecosystem has received inadequate attention.

Dryland wildlife is best known through its endangered species, the symbols of which include the rhino, the elephant and the impressive large herds of herbivores in eastern and southern

Africa. These have become important sources of income through conservation campaigns, game hunting and ecotourism. However, the popular scientific media has also popularized the image of drylands as harsh environments where only scorpions, snakes and specially adapted creatures (including man) can survive. In many ways, this dramatization has been useful in getting extra attention for drylands, but it has also helped to prolong the myth that drylands must be “tamed” – i.e. they have little intrinsic value in and of themselves.

Protected areas have long been a major pillar of biodiversity conservation strategies. In Africa, for example, about 8.5 percent of the total land area of the continent is designated as protected area. Drylands have a slightly higher share than forests. About 16 percent of Africa’s population live within 20 km of designated protected areas and population growth in these buffer zones has been found to be higher than elsewhere. This is indicative of the importance of these sites for local people's livelihoods, and a clear warning of the weakness of the “pure conservation” approach.

3.3 Special features of dryland biodiversity

Dryland biodiversity has distinguishable features that are often overlooked. These include heterogeneity, remarkable diversity of micro-organisms, presence of wild relatives of globally important domesticated species, and traditionally adapted land use systems.

a) Diversity of habitats

Biodiversity in drylands varies among ecosystems, but also among habitats. Species, and management systems alike, have adapted to the heterogeneity and special driving forces. Of particular importance are the natural and human-induced habitats, such as those described in Box 2.

Box 2: Diverse habitats in drylands

Wetlands, oases and protected areas constitute islands of enhanced biodiversity in drylands. These are often the *life lines* and biodiversity hot spots of drylands.

Ponds, lakes and rivers are major poles of socio-economic activities with significant effects on biodiversity. Global significance of these habitats is increasingly realised. For example, migratory birds depend on these sites, such as the Djoudj national park in Senegal for survival (GEPIS, 2000). Another global dimension of these habitats is that degradation of the basins of transboundary rivers has serious repercussions for a huge population covering several countries.

Oases are small islands of greenery in the dry landscape. They are sites of intensive and highly productive systems in drylands. Accessibility to water makes these sites the engines of desert life. Biodiversity per unit land area is probably very high, although not well documented.

Groves. A grove is a forest patch. It may be a remnant of the original vegetation or not. Many groves are worshiped as shrines. Sacred groves and taboo species of animals and plants are part of a community’s cultural heritage of natural resource management and biodiversity conservation (Millar et al, 2000). Sacred groves, like oases, are biodiversity micro “hot spots”. The persistence of shrines and groves in many dryland rural communities despite degradation of the surrounding environment are testimony to their importance for these communities.

The many diverse habitats are important factors of intra-specific variation in drylands. Thus, although species richness is higher in tropical forests than in drylands, within-species diversity is probably much higher in drylands than in forest ecosystems, because of the isolation of populations. But there is a lack of reliable data to document this diversity.

b) Wild relatives of domesticated species

Historically, drylands have been the living basis for mankind. The first humans originated in the savannah grasslands of eastern and southern Africa. The origins of many of the earth's most important food crops are found in drylands. For example, maize, beans, tomato and potatoes originate from the drylands of Mexico, Peru, Bolivia and Chile. Millet and sorghum, and various species of wheat and rice come from the African drylands. The Mediterranean basin has given the world date palm and olive trees. And drylands continue to provide new food, as traditional food products are increasingly becoming commercialized globally in the age of health-consciousness (e.g. wild millet, wild rice, etc.).

c) Micro-organisms.

The world of micro-organisms is notoriously poorly documented. The level of biodiversity is unknown. The importance of micro-organisms, however, is well appreciated in food and pharmaceutical circles. Their ecological role is also crucial. In the particularly difficult environment of drylands, micro-organisms play a major role in key ecological processes that sustain the functioning of these ecosystems. In response to the inherently low soil moisture and nutrients (especially nitrogen and phosphorus) in dryland soils, there exist a great diversity of symbiotic associations between plants and micro-organisms which efficiently: (i) fix atmospheric nitrogen through legume-rhizobia associations and (ii) extract phosphorus, various micro-nutrients, and water under very low moisture conditions, through mycorrhizal associations. Also, some free-living organisms contribute significantly to the nitrogen balance of dryland ecosystems. Blue green algae, for example, have been shown to fix nitrogen in amounts large enough to partially offset nitrogen losses through burning (Medina and Huber, 1992). These are major assets of drylands with global significance

d) Agrobiodiversity in drylands

Agricultural biodiversity is a vital subset of biodiversity. It is the result of the careful selection and inventive development of farmers whose food and livelihood security depends on the sustained management of this biodiversity. Since the dawn of agriculture some 12,000 years ago, humans have selectively used and bred certain species of plants to provide food and other goods. These varieties of plants and breeds of animals, the species, and the agroecosystems that support them comprise agrobiodiversity (Mulvany, 1999).

Pastoralism : Dryland Herders Have Engineered Efficient Pastoral Systems and Promoted Livestock Diversity

Progress in range science and better appreciation for indigenous knowledge have increased our awareness of the resilience of rangelands and the reversibility of the alleged degradation of rangeland ecosystems (Denève, 1994; Benjaminsen, 1999). In fact, due to strong seasonal dynamics, the risk of overgrazing is limited to a short period in time. The two basic properties of dryland pastoral ecosystems, instability and resilience, support the continued practice of transhumance and of nomadism. Both methods of utilising grazing land resources are based on mobility and maximal dispersion during the growing season.

The new non-equilibrium ecological theory undermines earlier approaches to range ecology, and represents an alternative theory of the functioning of pastoral ecosystems. This approach stresses the need for flexibility and mobility in dryland opportunistic grazing strategies, principally due to the strong rainfall fluctuations found in these arid environments. There is now a greater appreciation of the efficiency of traditional pastoral systems based on mobility and the exploitation of extensive resources (Niamir-Fuller 2000).

In Australia, for example, rangelands have been shown to be remarkably resilient. Although overgrazing leads to reduction of vegetation cover in the shrublands, the system is known to bounce back to earlier vegetation type and species composition when favourable conditions return - i.e. reduced grazing pressure and better rainfall. It is only where extensive commercial ranching is practised that rangeland degradation becomes severe (Pickup et al. 1995).

In the Sahel, Denève (1994) reports that comparison of productivity between livestock in this ecosystem and ranches in Texas and Australia shows that animal productivity per surface unit is 1.5 to 10 times higher in the Sahel than in modern ranches. The author also challenges a rooted misconception about the role of livestock in desertification, indicating that when everything has been grazed, animals have to leave or die, but this does not mean that vegetation has disappeared. Indeed, like in the case of Australian rangelands, the capacity of the highly resilient vegetation of the Sahel to bounce back when good rains come after a drought period is impressive. Contrary to the widely held view that herders in their ignorance are raising their animals in an irrational way and destroying the environment, traditional herders have accumulated invaluable indigenous knowledge and skills for optimum use of their marginal land.

Dryland systems have in fact adapted to herbivory. Evidence shows that dryland vegetation can degrade if grazing is reduced or prohibited. Most drylands are grazing-dependent systems. But drylands are now seriously threatened and in some places have broken down, due to commercial (continuous, non-mobile) ranching in the case of Australia, or pressures to provide land for agriculture, human settlements, protected areas, etc. in the Sahel. The breakdown of the system has serious impact on the diversity of living organisms but also on the wealth of indigenous knowledge accumulated by traditional herders.

Indeed, as indicated above, indigenous pastoralists have acquired extensive knowledge of species, habitats and key ecological processes in grazing lands and have developed efficient management skills for these systems. In addition, they have contributed enormously to the promotion and conservation of great diversity in domestic livestock as illustrated in Box 3. All these assets may be lost if nothing is done to alleviate the root causes of ecosystem degradation.

Box 3: The role of indigenous knowledge and practices in domestic livestock biodiversity – A case from Africa

McCorkle (1999) reports that as many as 150 varieties of cattle, 60 of sheep and 50 of goats are currently found in Africa. There also seems to exist considerable biodiversity in horses, mules, donkeys, chickens, pigs and dromedary camels, although these cases have been less well documented. Indigenous practices to

Agriculture: Dryland Farmers Promote Agrobiodiversity in farming systems and crop genetic resources

Management of crop-biodiversity by local farmers in drylands dates back to the dawn of agriculture. There is general agreement that many cultivated plants originated from drylands, including species of sorghum, millet in Africa, beans, potatoes, tomatoes from Latin America, etc. Management strategies developed over several millennia have generated a vast array of farming systems and crop genetic resources.

◆ Diversity of farming systems

The last three decades of farming systems research have shown the tremendous diversity and vitality of many traditional cropping systems in drylands, as elsewhere. We now have a better appreciation of why farmers continue to nurture biodiversity despite pressures to convert to mechanized mono-cropping (Box 4). The reasons have to do with risk management, balancing long term ecological sustainability vs. short term gains, and multiple uses and products rather than specialization in productivity.

Box 4: Diversity in farming systems

In the drylands of India and Pakistan, for example, farmers still maintain many of their traditions of nurturing biodiversity of wild and cultivated food crops and medicinal plants, despite introduction of monocropping by the Green Revolution. In addition, the traditional reverence of Indian farmers for multipurpose trees such as *Prosopis cineraria* in croplands enhances agrobiodiversity.

In a study of indigenous practices in farming systems and crop planting methods in eastern Kenya, Mathenge (1999) described no less than 10 distinct farming systems with 6 different types for what outsiders would only refer to as one "slash and burn" system. The crop planting strategy also was found to be very diverse, with 6 different planting methods of mixed seed cropping in which seeds of more than one species are planted in one hole. One of the most commonly practised method is to plant millet, sorghum and cowpea in one hole.

Another major farming strategy in drylands is the deliberate preservation of valued trees and shrubs in crop fields, a traditional agroforestry system known as parklands. In West Africa, for example, *Faidherbia* (*Acacia*) *albida* parklands in semi arid and sub-humid areas are known to have sustained continuous cropping for generations without fallow periods. The system is similar to the *Prosopis cineraria*-based system in India.

Although biodiversity may induce reduced crop yields in many cases, through crop competition, farmers consider that the overall benefits of the biodiversity rich system override the shortcomings. During years of drought, annual crops may fail completely. Farmers then rely heavily on the products of trees and shrubs for survival. Even during years of good harvest, people depend on tree products for vitamins, minerals, medicine, etc. Also, trees and herbaceous hedges on farm contribute to increased carbon storage in biomass above and below ground, thus reducing emissions of carbon dioxide to the atmosphere. This runs counter to the widely-held view that conversion of natural vegetation to agriculture reduces biodiversity and carbon storage. Agroforestry systems in drylands need better documentation to shed light on this apparent paradox of agroforestry parklands that increase biodiversity and carbon stocks on-farm. This is clearly a dryland asset with global significance.

◆ Diversity of crop genetic resources

Promotion of crop genetic diversity is part of farmer's coping strategies for mitigating weather unpredictability; it also reduces the so-called "hunger period" by spreading availability of food products over time. For example, in mixed farming, green leaves from cowpeas may be harvested as early as 21 days after sowing, whereas early green maize harvest is done at 60 days and late material at 120 days. Potato farming communities in Cusco, Peru, are reported to be managing up to 150 varieties. This diversity is an important element of food security in rural areas.

Rubyogo (1999) investigated farmers' crop variety ranking criteria in Kenya and reports the use of the following criteria :

- Early maturity (drought escaping)
- Drought tolerant
- Stable and if possible high yield
- Pest/disease and weed tolerance

- Socioeconomic criteria - e.g. variety for market production or household consumption.

Farmers maintain different varieties of maize, sorghum and other crops for each of these objectives. Evidence from other dryland ecosystems types support these findings that farmers value having agricultural biodiversity in their farming systems. This has been the experience with millet farmers in Rajasthan in India, with sorghum farmers in Tharaka, Kenya, with sorghum and millet farmers in Zimbabwe, and with potato farmers in Peru.

Green pharmacy: Traditional healers are knowledgeable in medicinal plant diversity

Old civilisations in drylands, like everywhere else, care for medicinal plants because they have built up generations of tried and tested curative methods and products. In India, for example, Shankar et al (2000) reported that 4 671 plant species are used in folk medicine. Although not unique to drylands, it is a remarkable fact that the use of medicinal plants is a living tradition of dryland rural people. In addition to the "professional" healers, countless of millions of women and elders have invaluable knowledge of herbal home-remedies and food and nutrition. Much of this knowledge has begun to be documented, preserved and fed into *sui generis* systems of IPR around the world. More investigation and analysis would be necessary, for example, in correlating dryland epidemiology with pharmacopae, developing benefit sharing regimes, and enhancing effectiveness of remedies for countless of rural populations without adequate health coverage.

3.4 - Threats to Dryland Ecosystems and Species Diversity

Extinction is a feature of all biological systems, but extinction of global biodiversity is now proceeding at an alarmingly high rate. Before human life on earth, the speed of extinction was about one species per year. Today, the rate is estimated to be 1,000 to 10,000 times this natural rate. According to IUCN's 1996 "red list", about 34 % of all fishes, 25 % of mammals, 25 % of amphibians, 20 % of reptiles and 11 % of birds were threatened with extinction at that time.

It is generally agreed that the following five causes are responsible for the loss of biodiversity :

- Fragmentation, degradation or outright loss of habitats;
- Overexploitation;
- Pollution;
- Introduction of non-native (alien, or exotic) species;
- Climate change.

The specific contribution of each of these causes to dryland ecosystem degradation and biodiversity loss varies with regions. Examples are given below (PIED, 1995).

In Australia, 2/3 of the continent consists of rangelands, of which 60 percent are used for commercial extensive ranching worth an annual revenue of 2 billions Australian dollars. It is estimated that over the last century, 12 percent of Australian dryland mammals have gone extinct and 8 percent of bird species are under threat. Most of these losses occur in areas used for large scale commercial ranching which, therefore, is the main cause of ecosystem degradation and biodiversity loss in Australian drylands.

In the Indian and Pakistani drylands, the main threats are (i) overcutting of trees and shrubs for fuel and building material; (ii) large scale irrigation and expansion of agricultural fields; and (iii) urbanisation, mining and industrialisation. Wildlife and natural vegetation are thought to be severely affected, but tree-based and other diverse production systems contribute to diversification of agricultural production and enhancement of agrobiodiversity.

Latin American drylands experience overgrazing by goats and/or overexploitation of natural vegetation for fuelwood, but these do not seem to cause irreversible degradation. Major disturbances are caused by mining operations, irrigation and urbanisation. Increasing conversion of natural vegetation into commercial monoculture also cause serious damage to ecosystem integrity. Traditional farming systems, however, still retain high levels of agrobiodiversity.

In the African drylands, the Convention to Combat Desertification recognizes that poverty-induced overexploitation of the land are a major cause of environmental degradation. This occurs through encroachment of agriculture on grazing lands (marginal to cropping but high quality for wild or domestic animal grazing), and overcutting of natural vegetation for fuelwood. These problems are compounded by rapid urbanisation, with its concomitant exponential increase in demand for charcoal, other wood products, construction gravel and soil, and other natural resources, not to mention negative impacts from lack of waste management. All of these factors have caused severe disruption of the traditional pastoral and rainfed cropping systems. Mobility, which is key to Sahelian pastoral systems of transhumance and nomadism, as well as wildlife, is becoming increasingly difficult because of fragmentation or outright destruction of grazing lands by agriculture and human settlements.

The status and trend in dryland biodiversity can be summarized as follows:

- The status of biodiversity loss in wild species is poorly documented; it may be that endemism is still healthy in pockets and hotspots, but the viability of these populations is not known.
- Most likely, genetic diversity has decreased as specific populations have been wiped out.
- Species diversity in traditional production systems is relatively well retained in farmers' crop fields and family herds.

Degradation of habitats due to changes in land use is the immediate most serious threat to dryland biodiversity. This first and foremost affects wild biodiversity, but as populations increase, and the urban and industrial sectors are not able to absorb this increase, there will be pressure on agricultural land, leading to agro-habitat degradation as well.

New and powerful factors cause ecosystem degradation that are far beyond the coping capacity of the legendary resilience of dryland systems: commercial ranching and monoculture, mining and industrialisation, urbanisation and other forms of human settlements, widescale irrigation schemes, strictly protected areas, etc.

The root causes of these factors are population increase, decades of market distortions and disincentives that encourage natural resource exploitation and mono-cultures, at the expense of dryland adapted sustainable development. This has been compounded by the "benign neglect" of drylands (Swift, 1993). Loss of biodiversity caused by land use systems is further exacerbated by climatic factors at both local and global scales.

4. BIODIVERSITY, DESERTIFICATION AND CLIMATE INTERACTIONS IN DRYLANDS

The physical processes of land degradation, biodiversity evolution or extinction, and climate change are intimately inter-twined, especially in drylands (Lean, 1995). Land degradation reduces natural vegetation cover, and affects productivity of crops, livestock and wildlife. Soil micro-organisms are also affected through soil erosion. The loss of biodiversity likewise undermines the environmental health of drylands and makes them more prone to further degradation. The vicious cycle fuels increased soil erosion, which causes increase in sedimentation of rivers and lakes. This contributes to the degradation of international waters and affects biodiversity in rivers, lakes and coastal ecosystems.

Desertification is also related to climate in many ways. Degradation of vegetation cover decreases carbon sequestration capacity of drylands, thus increasing emissions of carbon dioxide into the atmosphere. But carbon storage capacity of drylands is poorly documented. Given the increasing recognition that many dryland plant species develop extensive below ground biomass, current estimates of C sequestration in drylands are probably vastly underestimated. In the Sahel, for example, tree below ground biomass has been shown to be as high as the above ground biomass, with roots extending to 70 m away from the trunk or as deep as 30 m (Jonsson, 1995). This is yet another manifestation of dryland adaptation.

Another link between desertification and climate is through the effect of dryland dust on atmospheric composition. Arid lands are significant contributors of dust. Reduction of vegetation cover caused by land degradation increases these effects. The exact pathways in which increase in atmospheric dust can modify climate is still hotly debated, but a recent study reported by NOAA has provided the first substantiated evidence that atmospheric dust can affect both regional and global climates. Periodic burning of savannah landscape has also been shown to have implications for atmospheric chemistry. Thus ecological processes in drylands influence local and global climate. Climate change in turn affects drylands biodiversity by influencing species distribution range, water supplies, heat extremes, the humidity and temperature of soils and thus the albedo.

The predicted global climate warming resulting from the build-up of greenhouse gases in the atmosphere is expected to have profound impacts on global biodiversity at levels that may compromise the sustainability of human development on the planet. Climate warming will cause, *inter alia*, higher evaporation rates and lower rainfall both of which are major determinants of dryland ecological processes. Simulation models of climate change predict shifts in species distribution and reduced productivity in drylands. Each one-degree rise in temperature is expected to displace the adaptation of terrestrial species some 125 km towards the poles, or 150 meters in altitude. Approximately 30 percent of the earth's vegetation could experience a shift as a result of climate change. Millet crop yields in Africa, for example are expected to drop by 6-8 percent. The yield decrease may even be as high as 11% and 38% in some localities more severely affected. The maize crop yield in Asia and Latin America may shrink by between 10 and 65 per cent. The expected impact on wild biodiversity is much less known or analyzed (see paper on Vulnerability and Adaptation in this series).

Simulation models by Sala and Chapin (2000) to assess biodiversity change over the next 100 years predict that dryland biomes such as savannahs, grasslands and Mediterranean ecosystems will be among the biomes experiencing the largest biodiversity change, and will be affected significantly by a combination of land use change and climate change.

The strong linkages between desertification, biodiversity and climate are a clear invitation to CCD, CBD and FCCC for more effective collaboration. Increased efforts and resources must be used to promote stronger synergies. Such collaboration needs to be effective all the way from the level of local communities up to national, regional and international levels.

5 - CONSERVATION AND SUSTAINABLE USE OF DRYLAND BIODIVERSITY-A CALL FOR ACTION

Past conservation efforts have focused mostly on (i) ex-situ conservation of major food crop genetic resources and (ii) in-situ conservation of natural systems in protected areas. Tangible results have been achieved in both cases, but serious limits and conspicuous outright failures have also been recorded.

Building on lessons learnt from past experiences, this paper argues that dryland conservation strategies must focus on *people*, the end-users of genetic resources, whether for present or future generations. In this context, and in line with the precepts of the Convention on biodiversity, successful management of drylands will depend on our collective ability to formulate and implement appropriate policies and design/conduct proper field activities. The main objective will be to maintain and restore dryland ecosystems through conservation, the sustainable use of biodiversity and the fair and equitable sharing of benefits.

Within this general framework, however, programmes and projects on the ground will have to be specific to ecosystem-types since ecological processes and root causes of land degradation vary between regions, as shown above. Very often the root causes can be traced to a history of well intentioned, yet misguided interventions. Enabling environments may have deteriorated to the point where conservation and sustainable use of biodiversity can only be part of integrated strategies to promote sustainable economic growth and social development.

5.1- Lessons Learnt From Past and On-going Efforts

◆ Ex-situ conservation

Various national, regional and international institutions, programmes and projects have participated in wide-range collections and conservation in genebanks of tropical food crop genetic resources, including dryland species (See Table 1).

Table 1: Sources for in-situ conservation of dryland crops

Center name and location	Crop
CIMMYT, Mexico	Wheat, maize, triticale
CIP, Perou	Potato, sweet potato, Andean roots and tubers
ICARDA, Syria	Lentil, faba bean, chickpea, barley and wheat
ICRISAT, India	Sorghum, millet, chickpea, pigeon pea and groundnut
ILRI, Nairobi (ex ILCA, Addis)	Grasses, legume and browse species

Source: IPGRI, 1993

Although this represents an asset of immense value, the limits of ex-situ conservation are increasingly recognized. Several weaknesses have been identified, including the fact that gene banks cannot evolve, or "store" the farmers' knowledge and experimentation that creates and maintains agricultural biodiversity. This problem is not specific to drylands but it is particularly significant in drylands. Migration of people caused by land degradation or displacement/resettlement projects seriously undermine the conservation of indigenous knowledge.

The limits of ex-situ conservation and the need to complement it with in-situ conservation have been discussed in detail throughout the Convention on biological diversity, and more specifically in its articles 8 and 9.

◆ **In-situ conservation**

In the past, in-situ conservation strategies have tended to focus mostly on parks and protected areas. There is increasing recognition, however, that it is no longer sufficient to protect isolated fragments of land and water, given the critical role of biodiversity in maintaining human livelihoods, and vice-versa.

Current approaches to both ex-situ and in-situ conservation have a common serious constraint that limit their chances of success and impact. The problem concerns the fair and equitable sharing of benefits arising from conservation and more generally, the issue of incentives for conservation. Passionate and emotional debates are on-going on the Trade Related Aspects of Intellectual property Rights (TRIPs).

Many stakeholders question the ability of TRIPs in its current approach to settle the issue of fair and equitable sharing of conservation benefits (Hosken, 1999). As early as a decade ago, Altieri (1990) wondered, « How common is our common future » given the divide between North and South on the issue. More recently, Plahe (1999) referred to TRIPs as a "Licence to loot". The problem is not specific to drylands, but it has far-reaching implications on the future of global conservation. Finding the right approach that will ensure perceived fairness and equity in the sharing of conservation benefits between local communities, nations of origin and private multinationals remains a major stumbling block.

5.2- Framework for action

◆ ***Building on strengths***

In a radical departure from the pessimistic view about drylands, the proposed framework for action builds on positive and strong points that emerged over the last decade on the potentials of drylands, namely that (Benjaminsen, 1999; Toulmin, 1999):

- Drylands (rangelands and agricultural lands) are highly resilient and dryland people have developed indigenous knowledge and know-how to manage these lands productively and sustainably;
- Dryland Farmers and pastoralists value biodiversity in the management of their crop fields and family herds and actively create and maintain high diversity in traditional production systems;
- There is evidence that participatory involvement of local communities in identification of conservation priorities and sharing of benefits enhances the chances of success. Barrow *et al* (2000) have shown in Kenya that densities of herbivores increased in ranches where communities benefited from conservation, whereas densities decreased by 40-80 percent where there was no such organised and perceived equitable sharing of benefits.

The results also highlight the need for participatory involvement of civil societies in community-based conservation efforts. This requires the forging of partnership among a wide range of grassroot stakeholders: local NGOs, farmer organisations, women groups, individual conservation champions and/or opinion leaders, etc.

- The no-use preservation model of in-situ conservation does not work in drylands of developing countries where there is strong dependence of people on natural resources for survival. By breaking new and important grounds which reconcile the need for conservation with the concern for development, CBD provides a framework which puts conservation on a more favourable ground for adoption by dryland people;
- Globally, there are stronger legally-binding instruments for conservation today than there were before, at both national and international levels, prior to the Rio Conventions. CCD specifically addresses desertification issues and therefore focuses on drylands. CBD's article 20, alinea 7, stipulates that "consideration should also be given to the special situation of developing countries, including those that are most environmentally vulnerable, such as those with arid and semi-arid zones, coastal and mountainous areas";

◆ *Pillars for a plan of action*

Based on the main results on dryland biodiversity reviewed in this paper, and on the opportunities for dryland conservation as presented above, the current renewed interest for drylands should be seized to put the Global Dryland Partnership on a secure footing in order to address the enabling environment:

- *Documentation of status and trends.* There is urgent need to launch a concerted global initiative to ensure in depth documentation of dryland biodiversity and maintain a credible database. This can be done through desk reviews but will have to be complemented with field studies where required. This in turn will enhance the scope for advocacy. The vicious cycle is that low awareness about dryland potentials has a negative feedback on resource mobilisation. The proposed initiative will break this vicious cycle.
- *Capacity Building.* These include: incentive measures; policy reform; letting dryland voices be heard; resource mobilisation; relationship with other international Conventions. All of these will require a concerted effort at capacity building at all levels.

- Awareness and exchanges between regions. Research and training; sharing of information; technical and scientific co-operation

6- CONCLUSION

This review has highlighted the importance of drylands: extensive land areas which are habitat and source of livelihood for about one quarter of the earth's population. Drylands contain highly resilient species adapted to the seasonal pattern of rainfall and recurrent droughts that prevail in these ecosystems. These attributes have global significance in the context of predicted global warming.

Drylands have been neglected in both conservation and sustainable use efforts. It is therefore difficult to provide a definitive picture of biodiversity status and trends. We may conjecture that biodiversity in drylands survives in pockets and hotspots, or in transhumant and nomadic areas not affected by habitat conversion, or in traditional farming systems. But, following the precautionary principle, and until such time as additional data proves otherwise, it is safe to say that habitat degradation is an imminent and immediate problem affecting biodiversity loss in drylands. It is important that biodiversity in drylands be addressed in two parallel fronts: addressing potential and actual biodiversity loss, through documentation, advocacy, capacity building, and improvement of the enabling environment, and highlighting and encouraging instances where biodiversity is healthy and managed sustainably.

References

- Altieri, M.A. 1990. How common is our comm future? *Conservation Biology* 4 (1): 102-103.
- Arroyo, M.T.K, P.H. Raven and S. Sarukhan, 1991. Biodiversity. Invited communication at the International Conference on An Agenda of Science for Environment and development into the 21 st Century. Vienna, Austria. 17p.
- Barrow, E., H. Gichohi and M. Infield. 2000. Summary and key lessons from a comparative review and analysis of community conservation in Eastern Africa. IUCN Eastern Africa Working Paper No. 2. 25 p
- Benjaminsen, T.A. 1999. Communication at the brainstorming session on "Drylands, poverty and development: Towards a strategy for the World Bank". Washington, DC
- CCD Secretariat. 1997. United Nations Convention to Combat Desertification in those countries experiencing serious drought and / or desertification, particularly in Africa. Text with Annexes Geneva. 71 p
- Denève, R. 1994. Sahel - Sahel a controversial vision. IUCN Sahel studies. Cambridge/UK, Gland / Switzerland. 63 p
- GEPIS. 2000. Vers une gestion durable des plaines d'inondation sahéliennes. UICN, Gland, Suisse et Cambridge, Royaume Uni – xii + 214 pp
- Hosken, L. 1999. Biodiversity : Green gold or sacred teacher ? *Compass Newsletter for endogenous development* : 18-19.
- IPGRI. 1993. Diversity for development. The strategy for the International Plant Genetic Resource Institutue. IPGRI, Rome.
- Jonsson, K. 1995. Agroforestry in dry savanna areas in Africa: interactions between trees, soils and crops. Ph D Dissertation. Swedish University of Agricultural Sciences, Umea, Sweden.
- Lean, G. 1995. A simplified guide to the Convention to Combat Desertification, why it is necessary and what is important and different about it. The Center for Our Common Future. 32 p
- Mathinge, L. 1999. Indigenous pratices in farming systems and planting methods : A case study in Maragwa and Gikingo locations of Tharaka District, Kenya. Paper presented at the National Workshop on Agricultural Biodiversity. Nairobi, Kenya.
- Mc Corkle, M.C. 1999. Africans manage liverstock diversity. *Compas Newsletter for endogenous development* : 14 – 17
- Medina, E. and O. Huber 1992. The role of biodiversity in the functioning of savanna ecosystems. In : Solbrig, O.T, H M van Emden and P.G.W.J van Oord (eds), *Biodiversity and Global Change*, pp 139 – 158. IUBS Manograph 8.

Millard, D, R. Aniah and P. Atoyure. 1999. Shrines and groves. *Compas Newsletter for endogenous development* : 34-36.

Mulvany, P. 1999. The year of farmer's rights : local to international governance of agricultural biodiversity. Paper presented at the National Workshop on Agricultural Biodiversity. Nairobi, Kenya.

Niamir-Fuller, M. ed. 2000. *Managing Mobility in African Rangelands: The Legitimization of Transhumance*. IT Publications, London.

PIED. 1995. La diversité biologique dans les régions arides du monde. Version révisée.

Pickup, G., G.F. Griffin and S.R. Norton. 1995. Désertification et biodiversité dans les zones arides. Considérations régionales. Australie. *In* PIED (ed). la diversité biologique dans les régions arides du monde - Version révisée. Pp 67-85.

Plahe, M.A. 1999. Licence to loot : The Trips agreement and the threat to biodiversity. Paper presented at the National workshop on Agricultural Biodiversity. Nairobi, Kenya.

Redford, H.K, A Taber and J.A Simonetti. 1990. There is more to biodiversity than the tropical rainforest. *Conservation Biology* 4 (3) : 328 – 330

Rubyogo, J.C. 1999. The role of farmers' seed management systems in developing a sustainable seed sector. Paper presented at the National Workshop on Agrobiodiversity Nairobi, Kenya.

SBSTTA, 1999. Biological diversity of drylands, arid, semi-arid, savannah, grassland and mediterranean ecosystems. Draft recommendations to COP5. Montreal, Canada. 16 p

Sala, E.O and T. Chapin. 2000. Scenarios of global biodiversity. *IGBP Newsletter* 33 : 7-11

Shankar, D., A. Hafeel and T.S. Suma. 1999. Cultural richness of green pharmacy. *Compas Newsletter for endogenous development* : 10-11.

Swift, J. 1993. *Pastoral Development*. Thematic paper presented at the UNSO/UNDP Donor Meeting on Pastoral Development, 1993, Paris.

Toulmin, C. 1999. Price, institutions and partnerships : challenges for drylands Development. Summary presentation at the brainstorming session on "Drylands, Poverty and Development : Towards a strategy for the World Bank", Washington, DC

UNEP, 1999. Early warning of selected emerging environmental issues in Africa : change and correlation from a geographic perspectives. UNEP/DEIAEW/TR. 99-2, 42 p.

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