

## DESERTIFICATION AND DRYLANDS DEVELOPMENT: WHAT CAN BE DONE?

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### ABSTRACT

By analysing the concept of desertification and the evolution of its definitions, five main themes were selected. The perception of the causes of desertification has shifted from blaming colonization to climate change and finally to the traditional land-use systems. In the 1960s in Africa, the trend was to attribute land degradation to sectorial development during colonization. During the 1970s, essentially because of UNEP efforts, middle-term climate changes and short-term droughts were considered as causes of desertification, while distinguishing meteorological, hydrological, edaphic and agricultural droughts. The consensus view of the last decades now is that desertification is primarily human induced: among them the effects of traditional indigenous land management and of imported exogenous land management can be distinguished. To separate climate-induced, short-term environmental changes from land degradation induced by human activities is impossible.

What can be achieved in drylands? It is obviously erroneous to propose dry ecosystem development on the model of highly mechanized developed countries. Drylands development requires much more input, leading to accelerated waste production. It cannot follow the same scheme as in temperate or in wet-tropical ecosystems. They need higher investment and risk more irreversible land degradation. The drylands are financial sinks. Rehabilitation of the environment together with demographic control should have priority. Finally, preference should be given to small projects of irrigation rather than huge complex plans. © 1998 John Wiley & Sons, Ltd.

KEY WORDS: desertification; colonization; droughts; development; drylands; Africa (Sahel); Brazil (northeast)

### INTRODUCTION

*Desertification*, although difficult to precisely define, is for drylands the concept of overall environmental and socio-economic degradation. Definitions have multiplied and the lack of consensus during the Earth Summit (UNCED, 1992) did not solve the difficulty. The evolution of the concept will be analysed first. Then the role of desertification as a facet in the recent history of global environmental problems will be discussed. Finally, possible strategies of development compatible with sustainable conservation of dry ecosystems are presented.

### THE CONCEPT OF DESERTIFICATION AND EVOLUTION OF ITS DEFINITION

In its widest sense, *desertification* means an irreversible environmental crisis producing desertlike conditions or desertlike landscapes. Desertification could mean evolution from viable to non-viable land. In its global and practical meaning it implies a set of actions, the consequence of which is the degradation of the vegetation cover, the soils and socio-economic conditions. In any ecosystem the concept of desertification should indeed be approached through the notion of irreversibility, meaning that rehabilitation within one human generation is unlikely. Proven by field observations, air photographs and satellite image analysis, the

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simplest and most useful definition of desertification rejects the simplistic perception of growing deserts, but refers to transformation of vegetated productive land into unproductive land and more precisely to the appearance of desertlike landscapes and specific surface dynamics in semiarid and dry subhumid ecosystems.

According to the definition of the United Nations, the word desertification is restricted to drylands. This means in Africa that the areas affected are the arid (rainfall  $R < 150 \text{ mm yr}^{-1}$ ), semiarid ( $150 < R < 600 \text{ mm yr}^{-1}$ ) and dry subhumid ( $600 < R < 800 \text{ mm yr}^{-1}$ ) ecosystems, where rehabilitation is the most difficult and socio-economic impacts are the most severe.

From numerous definitions, the following five main themes can be selected:

1. Desertification is a set of biological, chemical and physical processes which converge to create desertlike conditions (Rozanov, 1990).
2. Desertification is a social problem, involving people at all stages, as a cause, and as victims as well of lower agricultural return and increasing poverty (Spooner, 1987, 1989).
3. Desertification occurs when land becomes irreversibly sterile in human time terms and with regard to reasonable economic limitations (Mainguet, 1994a, 1994b, 1995).
4. Desertification is the diminution or the loss of the potential for sustainable use (Warren and Agnew, 1988).
5. According to Dregne (1984), difficulty of seed germination is the fundamental criterion of desertification.

To this list we propose to add the characteristics of: degraded soil, reduced seed germination, decreased seedling establishment and production, and reproduction potential of plant cover exacerbated by changing soil characteristics. All of these lead to the general loss of resilience, which is further reduced by:

- loss of soil aggregation, the key indicator for resilience of a dry ecosystem;
- decrease of general topsoil infiltration capacity;
- decrease of soil water storage;
- loss of resistance to mechanical disturbance (splash erosion);
- surface water redistribution and soil water redistribution;
- a new threshold for runoff initiation.

## CHANGING PERCEPTIONS OF THE CAUSES OF DESERTIFICATION

The efforts to combat desertification in the second half of this century led the international community to understand the causes and to place priority on abatement at all levels. Three stages can be distinguished: shifting the blame from *colonization* to *climate change* and finally to the *traditional land-use systems*

### *Colonization – A Cause of Desertification?*

In the 1960s, after decolonization in Africa, the trend was to attribute land degradation to sectorial development which took place during colonization. During the 1970s, essentially because of UNEP efforts, middle-term climate changes and short-term droughts were taken into account as causes of desertification. Currently the consensus view of the last decades is that desertification is primarily human-induced (Hulme, 1989). 'It has become fashionable these days to speak of poverty as the cause and consequence of environmental degradation and thereby to focus efforts at combating environmental degradation on the poor' (Tiempo, 1994); in other words to shift 'the burden of the drought to subsistence-orientated peasants, pastoralists and rural workers', (Barraclough, 1994). This trend is well illustrated by an UNSO-UNDP survey, which also attempts to assess the degree of awareness by local populations of the present status of their environment and habitat, but also their degree of consciousness of the rate of change in the environment and the risk of desertification occurring in the future.

To speak about human-induced desertification means putting the blame of irreversible land degradation on human activities and to ascertain that socio-economically driven environmental degradation has a greater impact than climatically driven environmental change.

*Climate Change – A Cause of Desertification?*

*Distinction between droughts in terms of quality and time-scale.* Dryland climate is less stable than climate that of other tropical ecosystems. In addition, scarcity of surface water leaves people at threshold water quantities necessary for human wellbeing and survival. At ecosystems level climatic fluctuations are the rule and not the exception. Effects of drought, however, are forgotten almost as soon as the rainfall deficit is over and no programme of prevention against the effects of drought exist. There is general agreement that dryland environmental disasters result more often from short-term droughts than from long-term climatic aridity. Several types of *droughts* can be distinguished:

1. *Meteorological drought* occurs when rainfall is deficient. However, no satisfactory model to explain this drought has yet been provided, as climate systems are too complex. It is governed by what happens in the atmosphere, by oceans, glaciers, sea ice, continental ice caps, the Earth's solid surface and the living organisms in the oceans and on the land. The interactions between these various spheres are difficult to predict, not least because their respective processes occur on widely differing time scales. The typical equilibrium response times of the climate system's various elements range from a single day to a few centuries. (UNEP-GEMS-IUCC, -Fact-Sheet 3, h.d.).
2. *Hydrological drought* is expressed by the decrease of runoff in the rivers and decrease of lake levels, modified by the rill wash/infiltration ratio and by evaporation (which are mainly caused indirectly by meteorological droughts). Both types of drought result from short-term climate changes which are normal for dry ecosystems.
3. *Edaphic drought* occurs when the infiltration rate of the soil decreases and, by sealing (seed germination capacity is diminished).
4. *Agricultural drought* is defined by the deficit of water versus the needs of agriculture. Like edaphic drought, it is non-climatical, being caused by other than climatic factors.

*Traditional Land-use Systems – A Cause of Desertification?*

*Traditional indigenous and imported exogenous land management impacts.* The environmental impact of traditional land utilization, though almost disappearing due to growing population pressure, is like 'accelerated slow mining'. Rapid and recent socio-economic changes accelerate this ongoing process of land degradation.

The environmental impact of exogenous (imported) techniques and models of management through bilateral or international development projects, planned by those familiar with wetter ecosystems, is disastrous. A convincing example is to be found in the former USSR, where, in the 1960s and the 1970s, Moscow imposed on the Aral Sea basin all kinds of irrigation methods and canals, which caused the present Aral ecological tragedy (Létolle and Mainguet, 1993).

Another example is Kuwait. During the Gulf War, when human settlements were systematically destroyed, telephone and electricity lines cut and oil fields burned (starting with Wafra in 1991), it was easy to discern degradation of soils resulting from the digging of trenches and erection of walls and berms, the explosion of bombs and mines, trampling by troops, and transport of heavy vehicles. But, shortly after the war, it was difficult to differentiate in the grazing areas the part of soil degradation directly resulting from the effects of the war and land degradation which had resulted from the two preceding droughts. One was from 1960–70, (except for rain in 1961 and 1967) and the other one from 1983–87: they both exacerbated the overuse of land by grazing and by human-induced disturbance (Dumay, 1993). The Gulf War thus resulted in an environmental disaster, on top of the slower land degradation that had already taken place. This increased the availability of mobile sand, subject to aeolian deflation, as in the semiarid zones of Tunisia and the Sahel, where twentieth century human activities led to similar, but slower, reactivation and remobilization of the previously fixed sand dunes.

A third example is in the semiarid Brazilian northeast, where land degradation seems to result from a more complex conjunction of different processes. Four centuries ago, the progressive substitution of amerindian

sedentary activities for colonial nomadic land occupation, requiring clearing of the Caatinga (semiarid open woodlands), had caused serious land degradation. Since around 1860, the development of the Great Western Railway had a further catastrophic environmental impact by using the wood of the Caatinga for the railway sleepers and as a source of fuelwood. Nowadays, the wood of the Caatinga is mainly overused by brick-making and lime-kiln plants, potteries and bakeries, and for charcoal production and thousands of kilometres of continuous fences and other palisades for the enclosure of the grazing land of the different farms.

From the previous observations, two conclusions can be derived:

1. It is hardly possible to separate climate-induced short term environmental changes from land degradation induced by human activities. Therefore we refuse to distinguish *desertification* and *desertization*, the first referring to climate-driven natural change, the second to anthropogenic change. The latter term was not adopted by the international institutions.
2. It is not possible to attribute all responsibility for land degradation to human activities, because we are not able to distinguish the anthropogenic from the short term climate-induced changes. Besides, we follow Thomas and Middleton (1994) that . . . 'in the degradation debate, ultimately it is not possible to divorce environmental and economic aspects of the problem'. If in drylands environmental effects of short-term climatic changes are difficult to distinguish from environmental effects of human activities, how can desertification than be objectively approached?

#### DESERTIFICATION: A FACET OF GLOBAL ENVIRONMENTAL PROBLEMS

In 1927, in a famous paper 'Les forêts du Sahara', Lavauden launched the scientific usage of the word desertification 'dans toute la zone . . . la désertification, si j'ose dire, est purement artificielle. Elle est uniquement le fait de l'homme' (throughout the whole Sahara – I dare to say – desertification is fully artificial: uniquely man-made.)

Aubreville (1949) was the second who scientifically used the word desertification when, as a forester, he observed 'Ce sont de vrais déserts qui naissent aujourd'hui sous nos yeux, dans des pays où il tombe annuellement de 700 à plus de 1 500 mm de pluies'. (Actual deserts appear today under our eyes, in areas where the annual rainfall ranges between 700 to 1 500 mm). This statement by Aubreville results directly from field observations and, as all assertions resulting from field observations, needs our attention. The word was first used for dry-subhumid and humid environments. Aubreville, in his description of the degradation of the dry forest of the northern Oubangui-chair (presently République Centrafricaine), includes in it both soil and vegetation deterioration caused at least partly by human activities.

International interest for a better understanding of the arid zones arose in the 1950s prompted by the UNESCO Arid Zone Research Programme. Ten years after, 30 volumes of technical and scientific studies had been published by UNESCO and 200 arid zone research institutions had been created in all world drylands. Simultaneously, the environment became of great concern. In 1962, Rachel Carson wrote *Silent Spring*, popularising the link between of agrochemical pollution and ecological degradation. In 1972, the Club of Rome highlighted in *Limits to Growth* the danger of environmentally destructive agriculture caused by trying to give priority to economic efficiency.

These environmental questions, and the severe 1968–72 drought that struck the whole Sudano-Sahelian belt of Africa from the Atlantic coast to the eastern Horn, collectively led to the United Nations Conference on the Human Environment that was held in Stockholm in 1972. Governments and the international community formed a committee for the control of drought in the Sahel – the *Club du Sahel* (CILSS). This was created by the donors (OECD) to mobilize and coordinate assistance to drought-stricken countries; for the coordination of the UN contributions, the United Nations Sahelian Office (UNSO) was established.

In 1975, the drought came back. The General Assembly of United Nations called for the United Nations Conference on Desertification (UNCOD), held in Nairobi (Kenya) from 29 August to 9 September 1977. It

produced a *Plant of Action to Combat Desertification* (PACD), with 28 recommendations describing detailed actions and entrusted the United Nations Environment Programme (UNEP), to implement and the follow-up the PACD (UNCOD, 1978; Kassas 1995).

Long after the alarm about environmental vulnerability raised by Lowdermilk (1935) and Jacks (1939), the word desertification (as coined by Lavauden) made newspaper headlines, due to UNCOD, which proposed in 1977 a map of areas at risk of desertification. UNCOD also voiced a comprehensive definition, (p. 7 resolution number 7) which was propagated by the media:

Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished or destroyed the biological potential, i.e. plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in quest of development.

From 1977 on, the World Meteorological organization (WMO) developed the World Meteorological Project, indicating the part played by climate changes in land degradation. Later on, in 1985, the Food and Agricultural Organization (FAO), launched the Behaviour Project in Tropical Forests. Both organizations contributed much to the World Climate Conference in Geneva, 1989.

According to the *ad hoc* consultative meeting, Assessment of Global Desertification: Status and Methodologies which took place in Nairobi in February 1990 (UNEP 1991): ... *desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse human impact*. This definition was not acceptable to the Earth Summit in Rio de Janeiro (July, 1992), which defined desertification as ... *land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities*.

Within the context of the above definition, *land degradation* implies declining *crops*, deteriorating *vegetative cover*, exacerbation of external dynamics at *land surface*, qualitative and quantitative deterioration of *water resources*, degrading *soils* and *air* pollution; it is a point of evolution which leads to reduction of resources potential.

After UNCOD, some national plans were drafted. Despite the growing awareness of the desertification tragedy, very little follow-up was given to the Plan of Action. 'Much argument centred on the definition and nature of desertification and what could be done about it. Further difficulty and confusion arose because of inconsistencies in the scientific and technical information resulting from different and changing definitional bases.' (Cardy, 1994). In Paris, on 17 June 1994, a convention to combat desertification – Intergovernmental Negotiation Committee for a Convention to Combat Desertification (INCD) – was signed. What follow-up will that see?

#### WHAT SORT OF DEVELOPMENT FOR THE DRY ECOSYSTEMS?

##### *Development in Drylands Cannot Simply Copy Development in Other Ecosystems*

Because of limited surface water, low and erratic rainfall, recurrent droughts, high temperatures and evapotranspiration, thin vegetation cover which cannot suitably protect against wind and water erosion, skeletal soils poor in organic matter, it is obviously erroneous to base the development of dry ecosystems on the model of humid ecosystems. In the dry ecosystems, numerous changes contribute to long-term aridification, short-term droughts, or extreme annual and periodical rainfall. 'Both drought and desiccation in drylands may increase environmental susceptibility to human-induced degradation' (Thomas and Middleton, 1994). The effects of aridification and droughts, combined with agriculture and increasing population, are exacerbated by the potential for soil erosion. The limited resilience of the dry ecosystems requires more frequent fallows. However, all the observations confirm that the resilience is reduced after each drought, especially if the drought occurs simultaneously with population growth.

In the dry ecosystems, the vegetation cover is discontinuous and solar radiation reaches the soil. Charney (1975) has proposed that vegetation removal by overgrazing and felling of trees triggers an increase of the albedo (surface reflectance) which in turn increases the air stability and reduces convective rainfall. In the 1980s, research on this direct relationship between changes in the vegetation and rainfall led to modified views; other data should be taken into account: roughness of the topography, ground conditions (degree of humidity, temperature, evaporation), agricultural systems. Hulme (1989) suggested that the severe drought of the Sahel between 1968 and 1985 was caused by oceanic climate changes. Ten years after the end of the drought, there is still no agreement on the causes of the crisis but a main distinction was proposed between the causes and the parameters responsible for the persistence of dryness.

Degradation induced by agriculture in the drylands environment leads to both environmental degradation and lower production. The most traumatic degradation is not due to subsistence agriculture, but to commercial agriculture, for example cotton-growing in the northeast of Brazil and in the Aral Sea basin and groundnuts in Senegal.

As a basic rule, in all development programmes the specific natural constraints (carrying capacity) of drylands and speed of population growth should be determined. The more arid a climate the less demographic pressure can be tolerated. The more population growth the more a pastoral society, based on extensive use of the grazing land and a maximum mobility, evolves towards a peasant society with agriculture, fragmentation and clearing of the grazing areas and sedentarization. Also future ways of living should be addressed: mobile or not mobile, which cultures are optimum *vis-à-vis* the vulnerability of the landscape? For pastoralism, which animals? If the people are sedentary, how can pastoral exploitation become compatible with needs and greed of the people?

#### *Can Agriculture be Sustainable in Drylands*

Only under the following conditions:

- No deep ploughing because the soils are shallow and light.
- Reduced dependance on external energy and better of natural clean renewable energy (sun, wind power, water power, geothermal heat). Large-scale biomass energy cannot be envisaged (except in Brazil where ca. 40 per cent of the cars are using alcohol-based fuel) and that presents a severe handicap.
- Reduced use of fertilizers and agricultural chemicals. In the Aral Sea basin, the overuse of chemicals is responsible for dramatic surface and groundwater pollution.
- Appropriate scale of irrigation in tune with the amount of evapotranspiration, and risks of salinization, sodication and compaction: for example, surface and sprinkler irrigation are not suitable for dry lands.

#### *What then can be achieved in drylands?*

How can dryland resilience be recovered? Which techniques could upgrade productive capacities of current degraded land? How can these techniques be applied and assimilated by local people? Are tourism and industrial development feasible, knowing that they require large quantities of water and oil-based energy?

We are in fact not able to combat the recurrent droughts, understand the climatic *mechanisms*. We are not even able to combat in one generation the human-induced causes of desertification. Nevertheless, we should immediately undertake the battle against the physical *effects* of land degradation and begin to improve human resources, mainly by family education which is a huge task.

In any development programme for drylands, priority should be given to *rehabilitation*. All efforts in the Sahel should be concentrated on vegetation cover, especially autochthonous woodlands and forests (not monospecific plantations) for soil rehabilitation.

Successful examples are only piecemeal. Even in Australia, where technical solutions are tried out, they are disturbed by socio-economic forces. Therefore, rules-of-thumb need more attention: with less than 250–300 mm yr<sup>-1</sup> rainfall, drylands should be kept under pastoralism; above this level of rainfall, other agricultural activities can be adopted. Pastoralism is not to be considered a marginal activity and it is

necessary to invest in its improvement. To increase the productivity and pasture value patch reseedling or overseeding can be a contribution. These methods, as applied on American and Australian ranches, took considerable investments in sophisticated equipment, but it can be developed more modestly by local people elsewhere. To restore the pastoral value of abandoned land, one should at least start with measures against water and wind erosion. Improving camel-raising and pastoralism in the driest areas of Africa and Rajasthan (India) is feasible. Replacement of cattle by the Nubian goat was a fruitful measure in the State of Paraíba (northeast Brazil). Technical improvements should anyhow be generated within the agropastoral communities themselves, and can be encouraged by the appropriate government policies.

It is recommended to start first with the introduction of indigenous leguminous trees on cultivated as well as on grazing land, these provide a natural nitrogen-input, anti-erosive shelter and fruit and wood production. Furthermore, there should be the systematic introduction of windbreaks or shelterbelts to decrease potential wind erosion, evaporation and salinization.

When Cairns, *et al.* (1994) proposed implementing integrated environmental management for the United States, they did not emphasize how appropriate their ideas were for combating desertification. When they add that . . . 'a more harmonious relationship between human society and the natural life support system of the planet' must be achieved in the next century, again their suggestions should be applied to dry ecosystems, where the resource damage is most severe.

## CONCLUSION

As a conclusion it should be repeated that the natural characteristics of drylands prevent the use of schemes developed for temperate or wet tropical ecosystems. Development of drylands needs high investment over long time scales. The drylands therefore are financial sinks. The first duty of a developer is rehabilitation of the environment together with demographic control. Development should give priority to small projects rather than huge complex plans.

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