CHAPTER 4

FIGHTING DESERTIFICATION

Mélanie Réquier-Desjardins (OSS, Comité scientifique français de lutte contre la désertification), Sandrine Jauffret (OSS) and Nabil Ben Khatra (OSS)

Desertification, a phenomenon where the soil loses its productivity, is an environmental issue as well as being a question of development (Cornet, 2002). It is connected with anthropic action and climate variability but also with changes in biodiversity, particularly in the Maghreb (Hobbs *et al.*, 1995). Although specialists regard desertification in the North African steppes (Algeria, Morocco and Tunisia) as a matter of considerable concern, the wide range of statistics available and of disciplines mobilised as well as the absence of national reference standards are obstacles to the methodical analysis of trends in this field (Abaab *et al.*, 1995).

Yet monitoring the environment is a strategic challenge for the development of the Maghreb countries, as is evidenced by the numerous documents and national environmental action plans that have been drawn up since the Rio Summit in 1992 and by the fact that these plans are being translated into action through a growing number of projects for rehabilitating critical zones. If these information facilities are to be effective, to serve decision-making and to provide material for visions of development in the longer term they should be multi-sectoral with regular input at the regional, national and international level. The UN Convention to Combat Desertification (UNCCD) plays a crucial role in the monitoring and evaluation of the desertification process.

In the Maghreb countries, anti-desertification action, which has traditionally been defined and organised centrally by the State, has recently been integrated into the rural or economic and social development of the various countries. The extent to which the countries are endeavouring to implement the UN Convention is measured on the basis of an inventory of the projects and programmes that have been launched and the cost of those efforts. Although large amounts are quoted in the implementation of sectoral reafforestation and water and soil conservation programmes, it is difficult to measure how effective these schemes are. This is due on the one hand to the fact that the budgets that are actually expended are often lower than the amounts originally planned, with the result that the schemes fall short of forecasts, and, on the other hand, to the fact that the information on the schemes' impact on the living conditions of the population groups concerned – the primary objective of combating desertification – is inadequate. And lastly, developments in the rural world, which for several decades have been marked by major changes, particularly in the socio-economic field, suggest renewal of national methods and strategies for fighting desertification.

Definition and physical processes of desertification

How can this process be defined?

The definitions of the term of desertification have been many and varied (Aubreville, 1949; Le Houérou, 1962, 1968 and 1977; Dregne, 1977; Meckelein, 1980; Bernus, 1980; UNEP, 1991), but since the UN Convention to Combat Desertification was signed in 1994 the term designates "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities".

The Convention specifies that "land degradation" means "reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of the soil; and (iii) long-term loss of natural vegetation" (UNCCD, 1994).

Growing anthropic pressure is the main cause of desertification, and climatic conditions merely exacerbate the damage caused by human activity (Mainguet, 1994). Once certain processes get underway they can continue even if environmental conditions become favourable again (rainfall, nutriment inputs, etc.) and if anthropic activity diminishes.

Desertification processes and mechanisms generally become manifest gradually through changes in the composition, structure and functioning of ecosystems. Vegetation and soil can be regarded as two completely separate subjects, even if the phenomena are totally interlinked in nature (Jauffret, 2001). Changes in vegetation actually directly affect the functioning and structure of soils and vice versa.

The effects of desertification can be apprehended at several different levels:

- locally, through the loss of soil productivity and the erosion of fertility (cf. box entitled "The stages of desertification");
- at a distance, because wind erosion engenders phenomena of sand deposits in neighbouring zones, while water run-off causes spate and flood problems and the destruction of infrastructures (particularly roads); and lastly, it gives rise to uncontrolled international migratory movements.

Desertification in the Maghreb – an irreversible phenomenon?

North Africa is one of the regions that has become most vulnerable due to the consequences of the arid climate and the impact of human activities on the natural environment. Desertification problems are particularly acute in the steppe zones.[1]

1 - The arid steppes in the northern Sahara cover an area of 630,000 km² extending from the Red Sea and the Suez Canal in the east to the Atlantic Ocean in the West; the region is between the 100 mm and 400 mm isohyets of average annual rainfall.

The stages of desertification

In the case of vegetation that is under growing pressure, several major stages of degradation can be defined before the irreversibility threshold is reached:

- variation in biomass and in the composition of vegetation resulting from stochastic climate cycles and events (exceptional drought, fire, disease, etc.);
- changes in the composition of the flora through the action of grazing animals and through cultivation: regression of palatable plants (or those relished by livestock) to the advantage of less palatable species;
- replacement of steppe species by post-harvest species;
- decrease in diversity and productivity;
- reduction of the perennial plant cover, and decrease in plant biomass and plant volume; diminishment of the natural environment's potential for growth and reproduction.

This process can be adapted to characterise the gradual disappearance of animal populations (whether domestic or wild animals) in a context of desertification.

The degradation of soil quality, which goes hand in hand with the action of water, takes place in three separate stages:

1. modification of the state of the soil surface (forming of a thin crust, sand encroachment, etc.); degradation of the hydrous functioning (decrease in soil water avaibility, in water use efficiency and in infiltration capacity, increase in water run-off, etc.); erosion of fertility (organic matter level, nitrogen level, cation exchange capacity);
2. reduction of structural stability;
3. water or wind erosion;
4. anthropic salinisation as the result of unsuitable irrigation, which causes soil sterilisation.

This desertification is thus a continuing, progressive process which can lead to the irreversible transformation of the natural environment. There are thresholds for each stage that are connected with the climatic and geo-socio-economic contexts. It is the result of both natural phenomena and processes triggered by the misuse of areas and their resources by man. And it is only through intervention by man that it can be curbed and halted.

Sources: Adapted from Milton et al. *(1994), Cornet (2000) & Jauffret (2001).*

Drought, a structural factor in this region, is a natural phenomenon which aggravates the impact of anthropic activities and triggers desertification processes. Man has exerted many different forms of pressure in order to cover his various needs by exploiting plant resources, particularly for raising domestic animals – sheep and goats –, planting crops, and collecting firewood (Jauffret, 2001). At the beginning of the 1980s it was estimated that in Algeria, Morocco and Tunisia 80% of national territory was affected by desertification (Dregne, 1984).

The development of human activities in pre-Saharan Tunisia since the 1970s is presented below with a view to studying the causes and consequences of land degradation in the steppe zones in greater detail. As is the case in the other countries on the southern shores of the Mediterranean, ploughing, overgrazing, the eradication of woody vegetation and

the cultivation of marginal land that is vulnerable to erosion are recognised as the main factors of desertification in this region (Skouri, 1993).

The initial effect of overworking the soil, in particular by ploughing with poly-disc ploughs, is to totally destroy the plant species of the steppes, especially the perennial species. This lack of plant cover combined with reworking of the top layers of the soil results in considerable increase in wind erosion. In certain environments the original vegetation is thus destroyed and at the same time the top layers of the soil are loosened (Floret & Pontanier, 1982).

Where a fairly high stocking rate is maintained on rangelands that are often unproductive this also results in the reduction of plant cover with perennial species, the depletion of palatable species, the trampling and consolidation of the soil and in some cases the development of non-palatable species. Rangeland stocking capacity in Tunisia is estimated at between 0.15 and 0.2 sheep units per hectare (Chaïeb *et al.*, 1991). By the end of the 1990s, stocking rates had increased rapidly to between 0.25 and 0.70 sheep units per hectare (Genin, 2000), an increase that was connected with the increase in livestock but also with the extension of agricultural acreage and the ensuing reduction of rangeland areas (Le Floc'h, 1976). The ill effects of overgrazing, which take longer to materialise than those of ploughing, have become visible and have resulted in the rapid decline of rangeland plant cover, which is a cause of concern.

The practice of taking woody shrubs and bushes for domestic energy (firewood) has resulted in the disappearance of the higher tree and shrub stratum of the steppes. Some experts (Floret *et al.*, 1978) stress the real gravity of the phenomenon in this context, since the fact that the roots are taken prevents the bushy tufts, which "produce" the most wood, from growing again, with the result that people have to "pick" smaller and smaller plants that are growing more and more sparsely.

There are several sociopolitical factors which explain these changes. Development policies in particular have promoted the expansion of cultivated land to the detriment of collective rangelands without clearly measuring the impact of this development in terms of desertification. As the result of three policies – nomad settlement, [2] privatisation of collective land[3] (Auclair *et al.*, 1996), and gradual integration of the region into the national economy (Auclair & Picouet, 1994) – more and more steppeland has been cleared and cultivated for cereal crops, which have expanded rapidly to fulfil the dual purpose of increasing the living standards of the local people and providing access for them to private land ownership.

The combined effects of drought and growing anthropic pressure on land and plant resources in North Africa have induced many forms of ecosystem malfunctioning and loss of biodiversity in these regions. Due to its climate, North Africa has a vast number of diversified landscapes and environments, and many types of ecosystems can be identified: coastal, insular, mountain, desert, oasis and humid zone systems. Part of the Mediterranean biodiversity hotspot, which has some 25,000 plant species and 14 endemic species, is located in Africa (Quézel *et al.*, 1999). The flora of the North African steppe,

2 - combined with a natural growth rate of 0.8% in the period from 1956 to 1994.
3 - Privately owned land accounted for 10.7% of the agricultural area in use in 1970 and 67.5% in 1996.

for example, comprises 2,630 plant species that are known as species of the Saharo-Arabian zone: 60% are species with Mediterranean affinity and 30% with tropical affinity. With 687 endemic species, the endemism rate in the North African steppes is 26% (Le Houérou, 1995 and 2001).

Experts (Floret *et al.*, 1990) refer to a series of research projects conducted in the northern and southern Sahara and underline the following: "Anthropic disruptions induce the depletion of natural vegetation, soil degradation (water and wind erosion), and deterioration of the soil water regime, and they reduce the efficiency of water use by plants." The consequences of these disruptions thus affect the biological resources and potential of land, and they in turn cause disruptions in the course of human activities, which can go as far as causing populations to abandon the land and to emigrate to zones considered to be more hospitable. The fact that these population groups are concentrated on the least arid parts, particularly the dry sub-humid zones, increases the risks of environmental deterioration of these formerly relatively stable regions, causing the impoverishment of the agricultural world (ROSELT/OSS, 1995).

Erosion phenomena are now developing in the cereal-growing plains in central Tunisia, which were formerly spared, and on the slopes of the ridge of the country. This anthropic stress on natural resources is compounded by a higher frequency of drought in the north of the country since the 1980s, as transpires from the climate surveys on the last 30 years conducted by the Tunisian national meteorological institute on the basis of the rainfall data measured at the meteorological stations.[4]

Monitoring desertification and the environment

The UNCCD and desertification information systems

Following the Rio Summit in 1992, the international community adopted the United Nations Convention to Combat Desertification (UNCCD) in 1994. There are now 193 States that have signed the Convention, whose principal objective is "to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas." (UNCCD, 1994) This Convention is the foundation of anti-desertification efforts in a decentralised bottom-up approach that is based on the participation of local population groups.[5]

Its implementation at the regional and sub-regional level involves the designing of regional and sub-regional action programmes to fight desertification. The Maghreb Arab Union (MAU) drew up its regional action programme in 1999 as a framework for dialogue,

4 - These studies calculate the Standardised Precipitation Index (SPI) on the basis of the monthly data available in the stations. They identify the periods of drought that have been recorded since 1940 (at the stations) in the various regions of Tunisia over different time steps (from one month to one year). Drought frequency has increased on the whole throughout the country since the 1980s. It should be noted that, contrary to the 20 previous years, there were more meteorological droughts in the stations in the south of the country during the period from 2001 to 2006 (Laatiri, 2008).

5 - It gave new impetus to the action plan to combat desertification that was adopted in Nairobi in 1977 at the United Nations Conference on Desertification, focusing the debate on the future of the populations concerned.

coordination and action. Three of the seven components of this programme concern measuring and monitoring the phenomenon and involve the creation of a database and a system for circulating information on desertification in the Maghreb, the evaluation of the status and dynamics of desertification, and the establishment of a regional network for constant ecosystem monitoring (General Secretariat of the MAU, 1999).

The national action programmes to combat desertification are strategic tools for implementing the Convention at country level. They are drawn up and implemented under the responsibility of the individual countries, and they develop many aspects connected with desertification, promoting in particular the establishment of information systems on desertification (cf. box entitled "National action plans to combat desertification – the examples of Algeria, Morocco and Tunisia).

National Action Programmes to Combat Desertification – the examples of Algeria, Morocco and Tunisia

The national action programmes to combat desertification are the strategy documents drawn up by the various countries on a participatory basis in line with the principles of the Convention. The texts of these programmes:

- explain the procedures to be followed in this participatory approach and present the forms of dialogue used, often placing emphasis on the gender approach;
- form the link between the broader issue of desertification and the two other Rio conventions (biodiversity and climate) from the point of view of synergies;
- present the natural resources and constraints of the country in question, identify desertification factors and draw up a general inventory of desertification per major region or per major land use system as well as per acreage of endangered and desertified land; the figures quoted in the national action programmes are based on a compilation of many different scientific, sectoral and project documents;
- list the measures the State has taken to fight desertification, listing the details of the major reafforestation and water and soil conservation projects as well as rural development projects and projects for supporting crop and animal farming and improving rural infrastructures;
- present the institutional machinery that has been established to facilitate project implementation, in particular the decentralised setup and the national body that has been created for coordinating anti-desertification action – the UNCCD relay, which is generally accommodated in the Ministry of the Environment;
- describe all of the measures that must be taken in order to implement the national action programme and the UNCCD, sometimes quoting estimates of the cost of those measures, and make proposals as to how such action can be financed and the partnerships envisaged;
- underline the need to observe the status of desertification regularly and to monitor and evaluate the national action programmes mainly on the basis of the information systems implemented.

Sources: National action programmes of Algeria (People's Democratic Republic of Algeria, 2004), Morocco (Kingdom of Morocco, 2001) and Tunisia (Republic of Tunisia, 1998).

From local ecosystem monitoring to management: the ROSELT local observatory network

The network of local long-term ecological monitoring observatories (ROSELT/OSS) was set up from 1994 onwards in the arid zones of the Saharan periphery with a view to harmonising methods for collecting and processing ecological and socio-economic data.[6] A ROSELT observatory is an organised system for collecting, processing and analysing data on the environment so that information can be exchanged and knowledge can be updated on how ecological, social and economic systems are evolving and interacting. Its purpose is to provide decision-making products on a regular basis that are useful and comprehensible for policymakers and managers. In addition to monitoring the many different facets of desertification (ecology, biodiversity, uses of natural resources, climate) by producing targeted indicators on a regular basis, the object of this network is to understand desertification mechanisms and to anticipate them by producing forecasting tools.

In order to evaluate the changes that are recorded in the observatory monitoring the steppes of the high plains south-west of Oran (Algeria) and in the Menzel Habib Observatory (Tunisia) in the period between 1970 and 2000, a multi-data analysis was undertaken in which land use maps drawn up on various dates were compared. Both of these observatories are situated in the North African steppe plains, and the data they collect are representative of the desertification problems encountered throughout the sub-region. The comparison highlights the same phenomena in both locations:

- degradation of pastoral areas (*Stipa tenacissima* or alfa grass steppes in Algeria and *Rhanterium suaveolens* steppes in Tunisia), with a marked decrease in area in both observatories;

- a change in steppe physiognomy and a decrease in the grassland quality of the steppes due to changes in flora composition, and in particular to the fact that good pastoral species (perennial grasses) or species with a high economic value (esparto grass in the plains in the case of the Algerian observatory and in the mountain regions in the case of the Tunisian observatory, a species used for producing paper) are disappearing (or becoming extremely depleted) and being replaced by less valuable species in terms of grazing quality (such as *Lygeum spartum* in Algeria and *Astragalus armatus* in Tunisia).

Alfa grass disappearing in the Algerian observatory

The observatory in the steppes of the high plains south-west of Oran (Algeria) is situated in the western part of the high steppeland plains and covers an area of 1,548,000 hectares; it has twelve municipalities characterised by rapid population growth and urbanisation: 63% of the population live in agglomerated housing units in 1988.[7] Sheep-farming is still by far the major economic activity, accounting for almost 80% of the local economy. The activity is in decline, however, since only 25% of the working population were occupied in sheep-rearing in 1998, compared to 75% in 1966. Crop-farming is progressing on the other hand.

6 - The pilot network is composed of 11 observatories in 10 countries: Algeria, Cape Verde, Egypt, Kenya, Mali, Mauritania, Morocco, Niger, Senegal and Tunisia. A total of 30 observatories are now involved in the ROSELT network, which has been financed mainly by the French Cooperation and Research Agency and by the Swiss Cooperation Agency.

7 - National Statistical Office, Algeria.

The three monitoring stations represent the main types of steppeland and the major constraints and perturbations to which they are subject. When they were set up their physiognomy was marked by three main features related to the three predominant species: esparto (*Lygeum spartum*), alfa (*Stipa tenacissima*) and white artemisia (*Artemisia herba alba*).

Analysis of the trend in land use in the period from 1978 to 2005 reveals that the "steppes" have undergone major changes both in terms of flora composition and as regards the area of their various physiognomical units, the prominent features being a decrease in alfa steppeland from 520,000 ha in 1978 to 140,000 ha in 2004, a decrease in white artemisia (13,000 ha in 2004 compared to 130,000 ha in 1978), and a decrease in a esparto grass (58,000 ha compared to 570,000 ha) (ROSELT/Algeria 2005). This estimate actually masks a further decrease – that of the density of the predominant species. Compared with the status in 1978, by 2004 54% of the plant landscape was composed of ecologically less demanding and/or low-palatability species (steppes referred to as "degraded steppes"), which had replaced the former predominant species. As regards plant cover, by 2004, the overall vegetation cover was less than 10% on 85% of the observatory area. In this observatory the land is used predominantly as pastureland, and the degradation that has been recorded is to be explained virtually entirely by overgrazing (cf. Map 1).

The destruction of alfa has been caused by overgrazing, which is surprising given its low palatability. The plant has been consumed massively as an ordinary "straw" combined with feed in the form of external feed concentrates (Aidoud & Nedjraoui, 1992). It has also been overexploited for manufacturing paper pulp. The irreversible loss of alfa, which is now acknowledged – it is difficult to regenerate – has resulted in the local extinction of numerous species which were ecologically specific to the plant. Although most of the species involved are neither rare nor endangered, this "extinction" is nevertheless a significant ecological event, since it indicates that an entire ecosystem encompassing both the biocenosis[8] and the ecological resources connected with it has been lost.

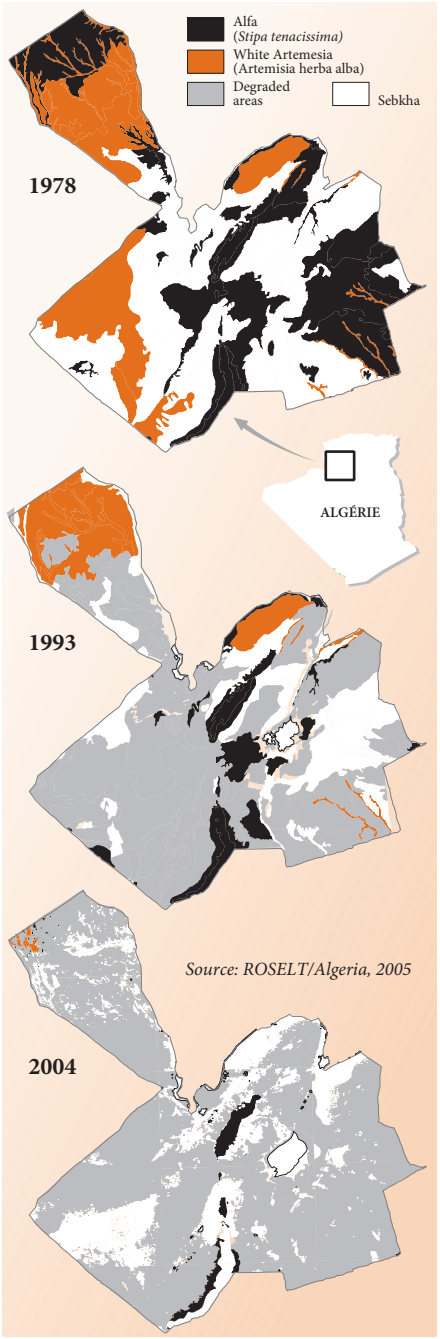
Some ecological systems are no longer in equilibrium with current ecological and economic requirements. The experts regard them as relicts which may be irreversibly lost as the result of a major environmental crisis. The decrease in alfa in the Algerian steppes has been rapid compared to the trends in Morocco and Tunisia (Le Houérou, 1995). It has certainly been promoted by a particularly unfavourable economic trend to which the resistance/resilience of the species and the ecological system has been inadequate. Other species or systems such as those involving artemisia or esparto grass have proved to be more resistant.

Stabilisation of desertification in the Menzel Habib observatory in Tunisia

The Menzel Habib Observatory is situated in the low plains in the south of the country (at a latitude of 34° 00' and 34° 20' N, and a longitude of 9° 15' and 9° 58' E) and covers an area of 100,000 ha. It had a population of 11,700 in 1994, grouped in 1818 households. In addition to low rainfall, the other environmental constraints are due to low water and

8 - All of the living beings, animals, plants and microorganisms present in a station in a given period. A biocenosis is established in a biotope, which is sometimes also called an ecological niche. The biotope and biocenosis together form an ecosystem

Map 1 - Trends in land use in the steppe observatory south-west of Oran, 1978-2004



soil resources; the soil is particularly sensitive to erosion and its fertility is limited. The main plant communities comprise the following steppeland species:

- *Rhanterium suaveolens* on sandy soils,
- *Arthrophytum scoparium* on loam soils,
- *Artemisia campestris* in post-harvest communities that are replacing *Artemisia herba alba* steppe, and *Gymnocarpos decander* and *Atractylis serratuloides* on crusted soils,
- *Stipagrostis pungens* on stable sandy dunes.

At the socio-economic level, the last four decades have been marked by major changes which have radically modified the environment and how it is used as well as lifestyles and how people adapt to new circumstances. Population growth, the settlement of pastoralists, land privatisation, the liberalisation of the economy, and the "modernisation" and expansion of agriculture are all factors of the ecological and socio-economic dynamics of the region.

Far-reaching changes were recorded in the observatory in the period from 1975 to 2000 (Le Floc'h *et al.*, 1995; Jauffret, 2001; cf. Map 2). *Rhanterium suaveolens* pastureland on sandy soils has been decreasing – either as the result of cultivation (and in particular through soil truncation), or because of overgrazing – and *Stipa tenacissima* (alfa) steppes have been virtually lost. White artemisia (*Artemisia herba alba*) steppes seem to have progressed as the result of a grazing ban. Since this steppeland is frequently cultivated, another variety of artemisia, *Artemisia campestris*, which can be described as a post-harvest species, is predominant. It is also observed that Astragalus armatus facies are expanding; the grazing value of this plant is virtually nil. Practically all of the steppeland area where there is water run-off

has been cleared. Cereal crops are now grown on sandy soils, which were formerly reserved exclusively for extensive grazing. These changes in use exacerbate the omnipresent erosion phenomena – wind erosion of sandy soils and water erosion of loamy soils. In addition to the agricultural activities that are expanding, the main forms of steppeland use are grazing on increasingly reduced areas of rangelands – hence the overgrazing – and the collection of woody shrubs and bushes for use as domestic fuel and as a source of fibre for local crafts.

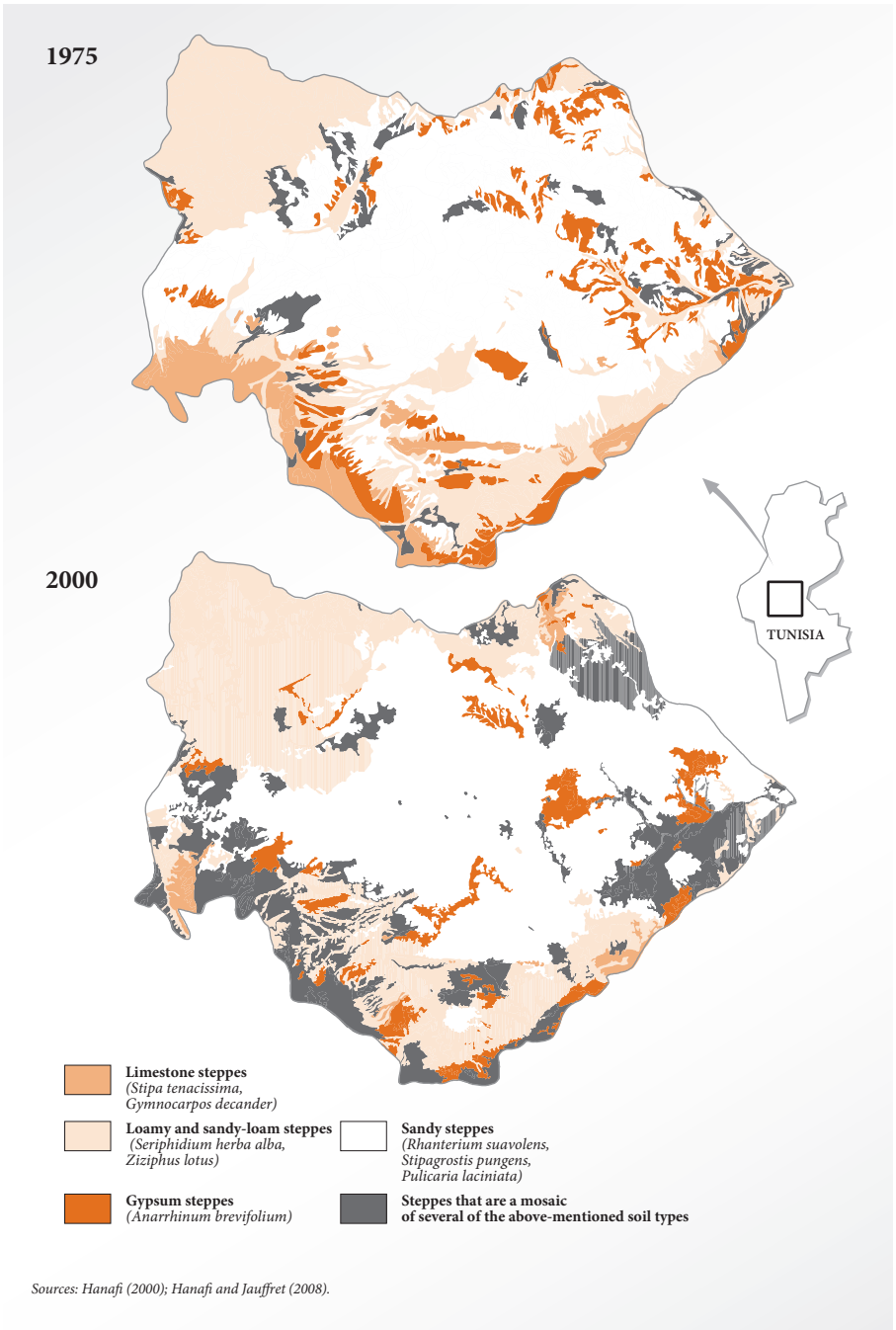
However, comparing the status in 1978 and 2004 masks to some extent what has really been happening in the course of the last 25 years. There was in fact an "active" phase of degradation in the form of considerable sand encroachment on the area under review, and by the end of the 1980s the plant cover had decreased considerably (Auclair *et al.*, 1996), as is revealed by a series of intermediate Landsat MSS satellite images). This erosion has been partially stabilised as the result of extensive development work financed by the State, and the plant cover will probably grow again at least on the fallow land. There may have been a series of different scenarios, at least as far as the "cultivated" area is concerned. The question that comes to mind is thus whether a new dynamic is not in fact being created by the "corrective" action combined with the diversification of households'economic activities – for people are tending to seek work outside the area and outside the agricultural sector –, the decrease in population that has been recorded in the observatory, and the increase in large farms practising intensive agriculture (Sghaier *et al.*, 2008). According to the experts, this new dynamic is marked to some extent by the replacement of species and the predominance of Astragalus armatus on Rhanterium suaveolens steppes and of Artemisia herba alba on post-harvest fallow land, and the low rates of perennial plant cover are possibly temporary in certain environments that are slower to regenerate. Regular updating of the vegetation sequence maps and ecological systems according to the methodology proposed above would provide a basis for establishing a new process for monitoring trends in the arid areas of Tunisia based on remote sensing.

The far-reaching changes in the ecosystems that are now affecting both observatories are due essentially to overgrazing and to the expansion of cultivated areas. The same trends have been observed in the Oued Mird observatory in Morocco (Yassin *et al.*, 2005). But in the Tunisian observatory refined analysis combining trends in household behaviour and household use of land tends to show that new trends are underway and that desertification has been stabilised to a certain extent.

Tools for concerted action in the elaboration of local plans

Modelling work has been developed within the regional ROSELT network, particularly in the Tunisian observatory, on population and environment interaction, the purpose of this local-level environmental information system being to carry out prospective simulations of desertification hazards (Loireau, 1998; Loireau *et al.*, 2008). The system provides a basis for assessing crop-growing, animal husbandry and wood collection practices, establishing the ratio of the resources used to the available resources in the observatories within the framework of spatialised models. The simulations that are carried out provide a basis for measuring desertification hazards and identifying the most vulnerable areas. Two simulations are presented below concerning the Menzel Habib

Map 2 - The Menzel Habib region: a landscape now heterogeneous and fragmented



Sources: Hanafi (2000); Hanafi and Jauffret (2008).

Atelier de cartographie de Sciences Po, 2009

observatory in Tunisia. The first evaluates the concomitant impact of stable population growth (equal to that recorded in the 1994-2004 period) and the doubling of stocking rate. The second simulates the impact of a 4-year drought by modifying the parameters connected with agricultural output and the quantity of plant biomass. The prospective maps that have been drawn up (cf. Maps 3 and 4) show that in both cases there is maximum risk of desertification in over half of the observatory area.

This tool has recently served as an aid for concerted action in the elaboration of the local action programme to combat desertification in the Menzel Habib zone.[9]

Evaluation of the costs of desertification in North African countries

Studies conducted by the World Bank in 2003, which are summarised below, evaluated the cost of land degradation for individual countries. In North Africa they concerned Algeria, Egypt, Morocco and Tunisia. A common analytical framework was used throughout, and a distinction was made between the consequences of such degradation for health and quality of life on the one hand and for the country's natural capital on the other, in the case of six environmental categories: water, air, soil, forest, waste, shoreline, plus the general environment (climate and biodiversity). The present section focuses on the damage concerning the countries' natural capital.

The economic evaluation was carried out in three stages: identification of the types of damage and impacts per category, quantification of that damage and estimation of the damage in monetary terms. The translation of the data into commercial terms, that is to say, the fact that the prices of economic goods were used, limits the scope for taking many factors into account. Agricultural losses, water losses, wood losses and losses of non-wood forest products were the main losses considered. The quantification factors and corresponding values are presented in Table 1 below.

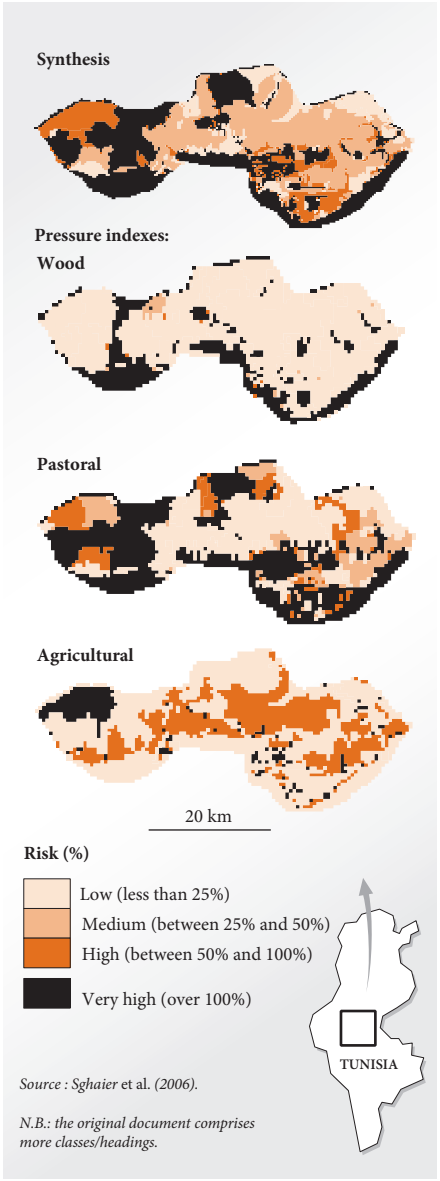
The cost of soil degradation amounts to around 1% of GDP in Algeria and Egypt and around 0.5% of GDP in Morocco and Tunisia. The same procedure was followed to establish all four estimates (Requier-Desjardins & Bied-Charreton, 2006):

- the degraded areas were quantified on the basis of cartography research and national or international censuses (FAO data);
- the loss of productivity was evaluated, generally on the basis of expert opinions or the extrapolation of local general-value surveys;
- the annual losses were then translated into monetary values on the basis of cereal prices – wheat and barley – and wood prices.

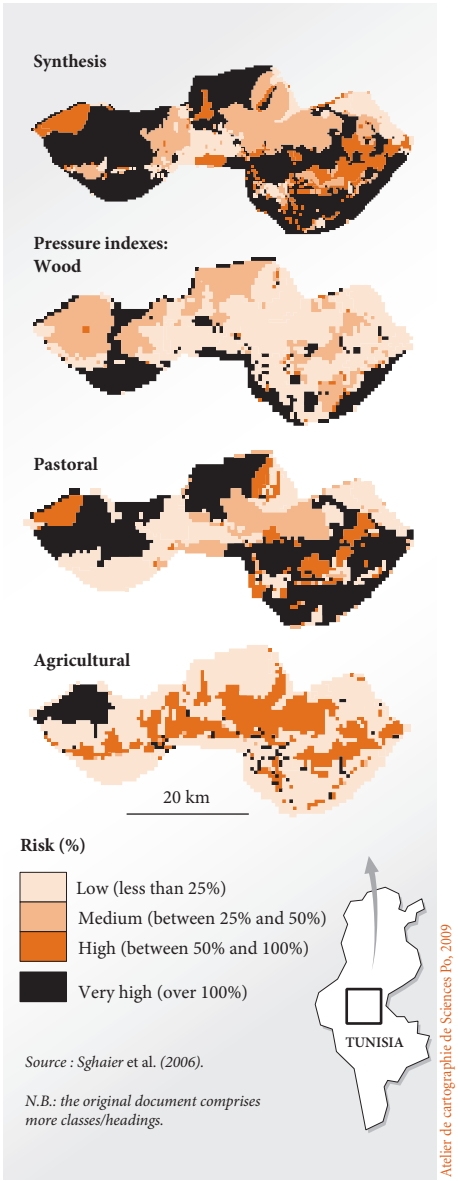
The information listed in the calculation columns is not homogeneous: the cost of rangeland degradation is not included in Tunisia; agricultural losses connected with the salinisation of soil is mentioned but not evaluated in Morocco (despite the fact that

9 - This experience is related on the site of the Tunisian Ministry of the Environment and Sustainable Development (www.environnement.nat.tn/indicateurs.htm).

Map 3 - Spatialisation of the risk of desertification, scenario 1



Map 4 - Spatialisation of the risk of desertification, scenario 2



irrigated acreage accounts for 15.5% of cropland); Algeria is the only country to take account of the impact of urbanisation on loss of agricultural acreage and production. These disparities illustrate both on the contextual nature of the evaluations (matching and relevance of the headings) and the data available for environmental monitoring (national statistics). The evaluations are general in nature, a fact which does not take

account of the wide diversity of agricultural production systems in North Africa: the quantifications are based on acreage under crop, mainly wheat and barley; the palm groves in the oases, tree farming (in particular olive groves) and the acreage under horticultural crops, which are also affected by desertification, are often omitted or are not included in any quantified analysis.

Table 1 - Annual impact of environmental degradation on the natural capital, 2003 (% of GDP)

	Algeria	Egypt	Morocco	Tunisia
Soil				
Erosion – agricultural losses	0.65	0.6-0.8	0.36	0.1-0.3
		0.4-0.6	No estimate	0.3
Irrigation (salinisation)		No estimate	0,05	No estimate
Soil – rangelands				
urbanisation	0,3	No estimate	No estimate	No estimate
SOIL - TOTAL	**0.95**	**1.2**	**0.41**	**0.52**
Water	0.62 Losses in the networks Silting	0.1 Fisheries losses	0.03 Silting of dams	0.06 Silting of dams
Water Quality/ecosystems	No estimate	No estimate	No estimate	No estimate
Forests* Woody vegetation and non-wood products	0.05	No estimate	0.03	Not significant
Forest/firewood	No estimate	No estimate	No estimate	No estimate
Air/agricultural loss	0.01	No estimate	No estimate	No estimate
TOTAL natural capital**	1.21 + 0.63 1.84	1.6	1.04	0.84
General environment Biodiversity	0.21	No estimate	No estimate	No estimate
General environment (CO_2)	1.20	0.6	0.89	0.59
Total cost ***	7.01	5.4	4.59	2.69

** Most of the forests are situated in mountain and coastal ecosystems.*
*** including the coastline.*
**** Air, water, soil, waste, forest, coastline, general environment (climate, biodiversity), impact on health and the natural capital.*
Sources: World Bank (2002 and 2003), Country reports, Metap (Republic of Algeria, 2002; Sarraf, Larsen & Owaygen, 2004).

The cost of desertification can also include the cost of forest degradation in that where there is a decrease in forestland and the areas concerned are not converted[10] this contributes to soil erosion and aridification. The estimates are based on the monetary evaluation of the quantities of wood lost as the result of forest fire and produce results which are of little significance at GDP level. The impact of the collection of firewood on the degradation of the natural capital has not been estimated. Yet in rural areas these wood collections are a common source of domestic energy, despite the fact that an increasing number of households are using butane for cooking and heating purposes.[11] And lastly, loss of biodiversity could also be part of the cost of desertification. However, the calculation of the costs available in the Algerian evaluation is based on an estimate of the average expenditure on the management of biodiversity parks, and the results thus do not concern desertification.[12]

If the cost of soil degradation alone is expressed in relation to annual agricultural growth in these countries, approximately 25% of agricultural growth would be cancelled out by these costs (agricultural losses). Yet in these countries the primary sector's contribution to GDP (around 10% to 15%) and the percentage of the working farm population (ranging from 20% to 45% depending on the country) are far from negligible (World Bank, 2008).

These surveys in fact propose measures for restoring the environment which cost much less than does degradation and which involve using water and soil conservation techniques and water quality and waste-water treatment methods, particularly in the case of oases and rural-urban fringe areas.[13] The evaluations are based mainly on the estimates produced in the countries'environmental strategy documents and action plans or on the extrapolation of the data available on specific projects to the entire territory (cf. Table 2).

Table 2 - Restoration costs as a percentage of (annual) GDP

	Soil	Forest	Biodiversity	Water
Algeria	0.94			0.70
Egypt	0.5 (erosion) 1.5 (salinisation)		No estimate	0.44
Morocco	0.04 (WMP, 1995)	0.11	No estimate	0.33
Tunisia	0.1 (NAP,1998)	0.04	0.02 (BDAP,1998)	0.35

NAP: national action programme to combat desertification
WMP: watershed management plan
BDAP: biological diversity action plan
Sources: World Bank (2002 and 2003), country reports, Metap (Republic of Algeria, 2002; Sarraf, Larsen & Owaygen, 2004)

10 - Conversion means transforming the ecosystem for a new use; it is different from restoration, which aims to restore biodiversity and functions (Aronson *et al.*, 1995).
11 - In 2000, the firewood collected accounted for 30% of total energy consumption in Morocco, 12% in Tunisia and 3% in Egypt.
12 - There is in principle no anthropic action in these protected areas.
13 - The costs quoted for restoring water resources also take account of the cost of rehabilitating infrastructures.

Regional monitoring of desertification: sensitivity to desertification in MAU countries

A map of sensitivity to desertification was drawn up in 2003 covering the Maghreb Arab Union. It was designed for evaluating readily available and compatible data at the MAU level in order to extract effective common indicators, and it pursued several operational objectives: locating major homogeneous zones in terms of natural resources, delineating cross-border environmental problems, highlighting the desertification hazards threatening the sub-region and, lastly, identifying priority target zones for measures to be implemented within the framework of the national action plans and sub-regional action programme to combat desertification. The factors indicating an ecosystem's sensitivity to desertification that were selected for drawing up this map are both biophysical (climate, soil and vegetation) and socio-economic (population, employment, customs and practices). The methodology adopted was based on the Medalus[14] approach, which takes account of the following four indexes: soil quality, climate quality, vegetation quality, and soil management quality.

Since there was no spatialised information available on the quality component of soil management, the socio-economic aspect was not taken into account in the first version of this sensitivity map. The map highlighted sensitivity to desertification progressing from north to south in the region, which was not surprising. This result is now a subject of controversy, however, particularly since the northern regions of the Maghreb are now more threatened than the southern regions, which have been affected by the desertification process for several decades.

Limits of the evaluations

Desertification is a multi-dimensional phenomenon concerning various sectors in the fields of agriculture, forestry, water management, environmental management, rural development and human (social) development. There are thus many different administrative departments in charge of supplying the necessary data for evaluating desertification, and coordination is essential. The most accessible data for the estimates carried out are biophysical, and the least available are socio-economic: the impact of desertification on households' loss of income is not known, for example; in particular, there are no statistics classed in a general typology of farms.

Establishing an information system at the national level which would provide a basis for measuring the physical phenomenon and for translating it into economic terms is a complex operation.[15] The reliability of data is limited on the whole: the absence of a system of reference impairs both the verification and the (multi-date) interpretation of the existing data; secondly, the choice of percentage of farmland and pastureland

14 - *Mediterranean Desertification and Land Use*: this project, which was launched in 1991 with the support of the European Union, models and quantifies the desertification processes in the Mediterranean region with a view to a better understanding of these processes, particularly in Spain, Italy, Greece and Portugal.

15 - At world level, the only study in which desertification is evaluated in both physical and economic terms was conducted at the beginning of the 1990s (Dregne & Chou, 1992). It estimates levels of desertification on a spatial basis, broken down according to how the land is used (irrigated agriculture, rain-fed agriculture and pastoralism), by crossing the percentage of the territory affected with the level of desertification. It calculates the costs associated with desertification by extrapolating micro-economic studies on per-hectare costs by type of land use.

affected is decisive. Various sources of figures actually quote results that differ considerably for the same country. Some estimates go as far as 100% of the territory affected and propose several degrees of desertification and differentiated productivity losses. And lastly, in these general approaches, farming practices, which are of crucial importance in desertification phenomena, are not taken into account to any great extent, or are not considered at all, in the evaluations carried out. The results presented are thus more estimates that are calculated according to a relatively well harmonised methodology at sub-regional level, which in theory provides a basis for cross-country comparison. These country results would seem to be relevant, however, since the statistics do not differ widely from one country to another.

Quantification of the areas affected by desertification provides a basis for developing arguments in favour of investing in action to combat the phenomenon. Cost measurement in particular is regarded as an institutional instrument, a strategic negotiating tool with which public funds and the funds provided through international cooperation can be attracted towards implementation of the UNCCD. This can result in overestimation of the areas affected (Jaubert, 1997) and thus of the costs involved. Consensus on terminology and methodology is absolutely essential to implementing regional monitoring of desertification.

Techniques for fighting desertification

The main techniques used in the Maghreb

In the countries of the Maghreb the rural populations have traditionally used techniques for maintaining and developing the natural environment, some of which date back to antiquity (Ben Ouezdou *et al.*, 2006). They have been improved over time and new solutions have also been introduced as a result of research, scientific experiments or innovations created by farmers themselves. From the beginning of the 20th century these techniques have been implemented through actions and projects conducted under the auspices of the technical services of the State in charge of area management and of action to protect natural environments (and in particular pastoral and agricultural environments). The anti-desertification measures or activities to conserve water and soil include mainly the following:

- grazing bans aiming to promote natural regeneration;
- structures for combating water and wind erosion such as:
  - the construction of *tabias* to supplement irrigation (soil banks that are sometimes raised by means of dried palms or sheets of fibre cement) or of *jessours* (dykes built of earth that are strengthened on the upstream and downstream face, with a central spillway) to protect cultivated plots from water erosion while promoting water infiltration;
  - the construction of dry-stone crests and terraces on sloping land;
  - recharge works (small gabion dams) and spate irrigation works (small dams linked to canals) accross the wadis for collecting and discharging water run-off;

– the erection of windbreaks with a sheet of fibre cement in order to limit sand encroachment in the steppes;

– the creation of *Eucalyptus sp.* forest plantations along roads in order to combat sand encroachment on highways;

– the creation of plantations of various tree species which stabilise shifting sand dunes (*Prosopis juliflora*, *Acacia horrida*, *Acacia ligulata*, *Acacia saligna*, *Calligonum sp.*, *Tamarix sp.*); a rooting rate of over 70% is required if this type of action is to be successful;

– the sinking of recharge wells for recharging aquifers (Ouessar *et al.*, 2006);

- action to build up forage reserves followed by the plantation of various species such as spineless and prickly cactus as well as *Atriplex nummularia*, which contribute to animal feed and help to reduce pastoral pressure on steppelands;

- the creation of tree nurseries in order to promote the multiplication of local species such as *Acacia tortilis subsp. raddiana*, *Rhus tripartitum*, *Periploca laevigata*, *Atriplex halimus subsp. schweinfurthii*, and *Retama raetam* with a view to reintroducing them *in situ*.

All of these measures promote steppe restoration through natural regeneration (grazing bans) and rehabilitation through the planting of trees and specific forage shrubs that are tolerant of arid conditions: *Cactus*, *Atriplex*, *Acacia*, *Agave*, *Prosopis*, etc. Remarkable productivity rates can furthermore be achieved with these shrubs with rainfall efficiency coefficients of 10 kg to 75 kg of dry matter per hectare per year and per millimetre that are 3 to 5 times higher than those registered under the same ecological conditions in steppelands with relatively minor degradation. It must be stated in this context that reseeding measures in the steppes have not met with any success worthy of note either in North Africa or in the Near East, despite several hundred attempts. Fertilisation attempts are inconclusive, particularly since aridity levels are high. Even when fertilisation is favourable from the technical and biological point of view, it is never economically justified in the case of steppe rangelands.

Jessours, *tabias* and small dams are used both for agriculture and for protecting the infrastructures and the towns and villages in the plains adjacent to the catchment areas. In the south of Tunisia, for example, the *Jessour* system is used traditionally for tree farming, particularly olive trees, and occasionally for a few annual crops. These structures are useful for mobilising water run-off along watersheds and are particularly efficient in years when rainfall is low. The *tabias* reduce run-off to virtually zero by reducing peak discharge (Nasri, 2002, cited by Ouessar *et al.*, 2006). They lack maintenance, however, and their constant deterioration can promote erosion. The recharge and spate irrigation works that are designed to recharge groundwater and to control flood water also allow the water to infiltrate the soil. Their retention capacity decreases with time due to the accumulation of the products of wind and water erosion and the silting that ensues. Surveys carried out on river basins show clearly that this recharge capacity decreases as one moves upstream. When technical facilities for combating desertification are not properly maintained or are used inappropriately they can themselves become vectors of desertification.

Factors of economic efficiency

The ways and means of combating desertification have been studied at length, and appropriate measures have been identified and improved over time. Few efficiency analyses have been carried out, however, or at least there is very little information on such analyses. Yet they would provide a basis for setting standards in terms of performance of practices in a given context and of cost-effectiveness.[16] Where such analyses are conducted they are generally carried out by teams of scientists in support of projects. The feasibility study carried out on a water and soil conservation project that was run in the Jeffara region in Tunisia between 1990 and 2000 is presented below as an illustration.

The Oum Zessar watershed in the north-west of the Jeffara region covers an area of 33,600 ha from the highlands down to the plain with a population of 25,000 people. The water run-off is estimated at 4.7 million m^3 per year. Large-scale development works were carried out in the period from 1990 to 2000 to curb erosion and desertification involving a State investment of 9.86 million Tunisian dinars. The activities focused mainly on developing watersheds (49%), mobilising water (22%) and maintaining and strengthening existing works (29%) (Ouessar *et al.*, 2006):

- creation of jessours, tabias and other anti-erosion structures extending over 7000 ha;
- construction of more than 175 recharge and spate irrigation works;
- installation of 10 recharge wells;
- repair and maintenance work on old anti-erosion works, and planting of trees, in particular fruit trees, with which 8500 ha of farmland can be conserved and consolidated.

The economic evaluation took account of environmental phenomena as well as economic and social effects (Sghaier *et al.*, 2002).[17] A representative sample of 120 crop farmers and animal farmers, 50 percent of whom benefited from these development works, were included in the survey in order to carry out this cost-benefit analysis. The economic return on the various land rehabilitation and maintenance techniques is first calculated (cf. Table 3): the jessours bring the best return, followed by the tabias and then by the dry-stone crests.

Table 3 - Variation in average agricultural output following measures to combat desertification (Tunisian dinars per ha)

	Jessours	*Tabias*	Dry-stone crests
Before (WSC)	182	26	27
After (WSC)	515	173	68

WSC: water and soil conservation
Source: Sghaier et al. *(2002).*

16 - Yield, or return in financial terms, is the capacity of capital to generate income – following an investment, for example.
17 - The FORCES-MOD model of the FAO and World Bank was used with a discount rate of 10%.

In order to calculate cost-effectiveness, the study estimates the variable costs (production costs in terms of labour, mechanical and animal traction and supplemental irrigation) and the various advantages brought by the works, including:

- increase in plant cover;
- expansion of fruit plantations and increase in cereal harvests in the area treated;
- contribution to the recharging of groundwater;
- improvement of the quality of life of the local people;
- reduction of the differences between the various levels of the watershed.

The rate of return is calculated over a 30-year period, which is considered optimal for maximising return on investment. The benefits brought by the project exceed the costs from the twelfth year onwards. The financial analysis covers all products which have a market price. The internal rate of return is relatively low: 5.5%.[18] The first economic analysis reduces market distortions (subsidies, taxes, etc.); this makes the investment more advantageous, since the rate goes up to 13%. The second (more extensive) economic analysis takes account of the reduction in costs relating to the (estimated) damage that would have been caused to infrastructures had these works not been carried out; it gives an internal rate of return of 18.44%. And lastly, the third (more extensive) economic analysis considers two favourable non-market impacts (or externalities) of the works involved in the project. One concerns the environment: it is the impact of the recharging of groundwater on the expansion of irrigated agriculture; and the other concerns the improvement in quality of life (estimated at + 5 Tunisian dinars per capita per year), which brings the rate up to 26%.

The rate of return varies from 1 to 5 depending on the factors taken into account in the valuation of the favourable impact of the project. This cost-effectiveness study provides a basis for listing and measuring all of the benefits generated by actions to combat desertification from the point of view of their contribution to local well-being (living standards and the preservation of natural resources) by expressing them in relation to their cost. It requires setting up a rather costly scientific survey and monitoring system. Within the framework of the measures to monitor and evaluate the UNCCD, the impact of these actions are measured in terms of quality for reasons connected with the human and financial capacities of the parties concerned.

Institutional response: monitoring and evaluating UNCCD implementation

The impetus provided by the Rio Summit in 1992

Monitoring and evaluation emerged in an international context that was marked by mixed results of several decades of programmes and projects for combating desertification and land degradation which had lacked focus. As a follow-up to the Rio Summit

15 - The internal rate of return (IRR) is the discount rate that delivers a net present value of zero for a series of future cash flows (generally relating to a project involving an initial investment followed by positive financial returns).

in 1992, many actors in the international community proposed work on the formulation of environmental indicators. The OECD first coordinated studies providing a basis for measuring performance in environmental management with a view to facilitating the elaboration of country reports on the state of the environment and proposing numerous indicators based on the "Pressure - State - Response" framework (OCDE, 1994). Then in 1995 the UN Commission on Sustainable Development had a series of 134 indicators elaborated for use by governments in their efforts to evaluate and list the progress made in the implementation of sustainable development, and the World Bank made a significant contribution to these efforts with its *Land Quality Indicators initiative* (Pieri *et al.*, 1995). All of this work contributed to the elaboration of monitoring and evaluation frameworks in the UNCCD context, whose purpose was to provide a frame of reference and steering tools for implementing the national action programmes to combat desertification. This vision is expressed specifically in articles 10.2 and 16 of the text of the Convention (UNCCD, 1994):

"Article 10.2: The national action programmes shall…. (g) require regular review of, and progress reports on, their implementation."

"Article 16: "The Parties shall, as appropriate,… c) support and further develop bilateral and multilateral programmes and projects aimed at defining, conducting, assessing and financing the collection, analysis and exchange of data and information, including, inter alia, integrated sets of physical, biological, social and economic indicators."

The approach developed by the Convention makes anti-desertification efforts an integral part of the strategies and programmes for developing arid regions (cf. box entitled "Country profile for the purposes of the UNCCD"). More specifically, the monitoring and evaluation framework validated by the international community at the Fifth Session of the Conference of the Parties held in Geneva in October 2003 comprises the following three components:

- observation and monitoring of natural environments expressed by monitoring indicators;
- evaluation of the results of anti-desertification action by means of implementation and impact indicators;
- assessment of the stage reached in the implementation of the commitments made by the parties to the UNCCD. The indicators adopted, which are known as progress and investment indicators, refer to the stage reached at the institutional level in the elaboration and implementation of the programmes to combat desertification and to the financial commitments involved.

These three components are integrated into a global mechanism which constitutes the information system on desertification.

Country profile for the purposes of the UNCCD

The country profile was adopted in 2003 with a view to harmonising the reports of the parties to the Convention on the impact of desertification and the remedial action taken. This multi-dimensional profile focuses on the two broad issues of the fight against desertification – the biophysical and socio-economic aspects.

Biophysical indicators of desertification and drought

1. Climate;
2. Vegetation and land use;
3. Water resources;
4. Energy;
5. Types of land degradation;
6. Restoration.

Socio-economic indicators of desertification and drought

7. Population and economy;
8. Human development;
9. Science and technology (number of scientific institutions working on desertification).

Source: UNCCD (2003).

Implementation of monitoring and evaluation in Morocco and Tunisia

In North Africa, the implementation of the monitoring and evaluation system has been supported by international cooperation. The system was developed in a harmonised sub-regional process (cf. box entitled "Implementation of the monitoring and evaluation process in Morocco and Tunisia") based on concerted efforts to develop three tools in collaboration with the national structures (OSS, 2006):

- the monitoring and evaluation indicators are designed to evaluate the measures taken to combat desertification; in theory, this pluridisciplinary information is provided at the sub-national level (implementation rate, impact) and then aggregated at the central level;
- the performance charts present the indicators that have been designed and calculated as well as factors pertaining to analysis and guidance for the decisions to be taken. They present the information in synthetic form and are designed to support decision-making at various levels (adopting of strategies, designing of projects, technical choices). They are first drawn up at the decentralised level in cooperation with the central administrative departments;
- the system for circulating information consists of a communication network linking various sub-systems, which produce and process the available information at a given level – generally the central level. The aim is to decompartmentalise institutional procedure in order to break with sectoral approaches for combating desertification

so that the monitoring and evaluation process can be integrated into the development process (Ben Khatra & Essahli, 2006).

Implementation of monitoring and evaluation in Morocco and Tunisia

The coordinated activities at the sub-regional level were carried out in three phases:

Phase 1: launching of the process (2002-2004)

- The methodology to be followed was distributed to all of the teams participating in the project.
- Efforts were then coordinated to adapt it to the specific features of the respective countries: training needs were identified, measures were taken to strengthen capacities, lists of monitoring and impact indicators were drawn up jointly and the calculation of these indicators was tested.

Phase 2: establishment of the various mechanisms (2003)

- The monitoring and evaluation tools and mechanisms were then established at the various levels, i.e. at the national and sub-national level in the case of Morocco and Tunisia, and at the sub-regional level in the case of the Maghreb Arab Union.
- The concomitant training was provided in the structures in charge of conducting the action programmes to combat desertification.

Phase 3: appropriation and internalisation (2004)

The national and sub-regional (MAU) institutions where training sessions had been held in the previous phases then disseminated the techniques and tools that had been developed.

Technical coordination at the sub-regional level facilitated the establishment of the monitoring and evaluation process: opportunities were provided for the various persons involved in the project to exchange notes on experience. With the support of the MAU this coordination promoted the integration of the monitoring and evaluation process into the national development strategies.

Source: OSS (2004).

Morocco and Tunisia created national frameworks for cross-cutting concertation in order to facilitate the implementation of this system and to integrate it into their development strategies,[19] and furthermore presented institutional innovations for the progress indicators in the reports they submitted to the UNCCD.

Morocco created a Directorate for Natural Resources and Action to Combat Desertification within the High Commission for Water, Forestry and Desertification Control. The network which this directorate coordinated with a view to defining and implementing the monitoring and evaluation process first elaborated a common model[20] for the fact sheets on the subjects considered to be the most crucial in efforts to fight desertification:

19 - More generally, monitoring and evaluating the environment is a recommendation that is put forward in strategy documents on sustainable development (Tunisia, 1995) and human development (Morocco, 2006).

20 - making a distinction between the broader issues, the main indicators selected, graphical illustrations, general assessment of trends, fields and recovery strategies.

socio-professional situation in rural areas, population trends and pressure on resources, water resources, forestry, pastoralism and rangelands, rain-fed agriculture, irrigated agriculture, oases, improvement of institutional organisation, improvement of knowledge of desertification (Wakrim, 2006). The indicators for monitoring and evaluating anti-desertification action were then selected on this basis; they are listed in detail in Annex 1.

In Tunisia, the National Council for Combating Desertification, which is composed of the main partners involved in the field, has the function of monitoring implementation of the national action programme on a regular basis; it also reports to the National Committee on Sustainable Development. As regards the actual concept of fighting desertification, Tunisia's efforts embrace a series of management and development actions, which can be physical, biophysical, socio-economic or institutional (Hajjej & Ben Khatra, 2006). The implementation and impact indicators for each action are integrated into the performance charts: the evaluation of implementation is quantitative (number of measures taken and what they have cost), and that of impact is qualitative.

The monitoring and evaluation process thus involves three levels of decision-making: the national level or strategy level, where information is centralised and the final decisions are taken regarding choices and methods; the sub-national level, where the operations are actually carried out and followed up; and the scientific level, where the measures taken to fight desertification and the monitoring and evaluation methods can be improved.

Assessment of results, limits and outlook

The purpose of monitoring and evaluation within the framework of the Convention is to produce the necessary information for the country reports which are drawn up on the stage reached in the implementation of the national action programmes and which evidence the progress made. The monitoring and evaluation process is designed as a central planning tool for each individual country and as a decision-making tool through which policies, strategies, programmes and projects for fighting desertification can be rationalised. It is part of a long-term strategy with two essential functions:

- the function of integration at the institutional level: the National Coordination Body is the official framework within which the actors in charge of managing natural resources and producing information on the environment coordinate their action;
- the function of improving and constantly updating knowledge.

The impact of the monitoring and evaluation process has been limited, however, in terms of institutional and organisational improvements. First of all, at the central level the fact that the national administrations are sectoral in nature remains an impediment to the sharing of information and the integration and perpetuation of the results produced by the various projects. Secondly, it has transpired that tools and methods are not transferred evenly to the decentralised level, where human and financial resources have proved inadequate for monitoring operations on a regular basis. The trend in current projects is now in fact to design monitoring and evaluation systems at the sub-national level in order to strengthen the links between the National Coordinating Body and the actors operating at the decentralised level. This decentralisation of monitoring

and evaluation should make it easier to adjust to local realities, since the capacities of the administrative units in the field will be strengthened. Caution is called for, however, when it comes to assessing the efficiency of this process. A long-term analysis of the arid zones in Syria puts forward the hypothesis that since the development of international law frameworks on natural resources is becoming an issue of international relations, the State is tightening up regulations and the decentralised application of these rules according to this umbrella legislation without taking account of local realities, and in particular of the way in which users negotiate and organise the use of their territories (Jaubert, 2006).[21] And lastly, the fact that the work on monitoring and evaluation that is underway in the Maghreb depends to a very large extent on international co-operation weakens the results achieved. By way of comparison, the box entitled "Stage reached in the monitoring and evaluation systems in the northern Mediterranean region" summarises the UNCCD's assessment of the progress made in those systems in the countries on the northern shores of the Mediterranean.

Stage reached in the monitoring and evaluation systems in the northern Mediterranean region

At the Conference of the Parties held in Madrid in September 2007, the UNCCD group of experts produced a document on the stage reached in the systems for monitoring and evaluating desertification in individual regions.

Northern Mediterranean: environmental monitoring is more a matter of research than a problem of sustainable development

In the northern Mediterranean countries, the system for monitoring and evaluating desertification is based on a full review of the national action programmes. Many indicators are available, but the quantitative data are often lacking. Desertification hazards have been mapped in certain countries or for certain regions. Multi-disciplinary and regional projects on desertification have been developed and produce figures, maps and models, but the results obtained are not used to an adequate extent in decision-making, since these indicators do not adequately meet the needs of users and natural resources managers. The supply of indicators thus does not adequately match demand.

Central and Eastern Europe: towards integrated systems for monitoring and evaluating desertification and drought

In most Central and Eastern European countries the databases and systems for environmental monitoring are structured essentially around biophysical aspects (vegetation, soil, hydrology, aridity, air quality, etc.).They produce mainly descriptions of desertification in terms of these biophysical parameters. Some countries in the region have developed integrated systems for evaluating and monitoring desertification at the national level, which include certain socio-economic data that are available, particularly for drought management.

Source: UNCCD (2007).

21 - It must also be stated that the UNCCD adopted a ten-year strategic plan and framework in 2007, which involves reexamining monitoring and evaluation from the point of view of performance indicators.

Public strategies and measures taken since the 1970s

The first techniques for fighting desertification were implemented back in the early 20th century and focused on containing the sand encroachment that was threatening infrastructures, particularly roads and urban settlements (OSS-CENSAD, 2008). Efforts to combat desertification were then combined with measures to support the advancing desert – a misinterpretation that is still widespread. In the three countries of the central Maghreb projects were launched from the 1970s onwards including in particular the Green Dam Project in Algeria, water and soil conservation policies in Tunisia and watershed works in Morocco.

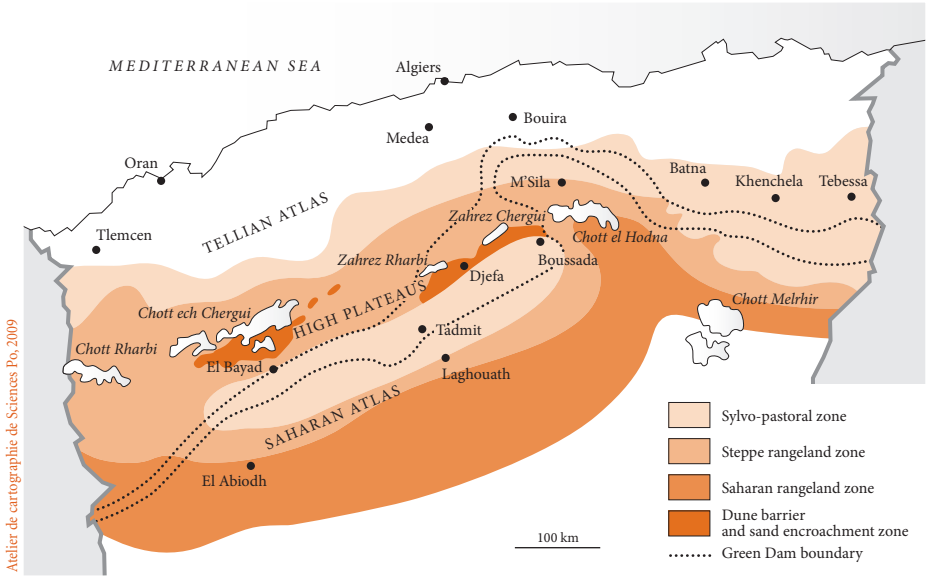
Algeria: from reafforestation to rural development (1970-2000)

The Green Dam is a project for the reafforestation of 3 million hectares rehabilitating the area with Aleppo pine on an arid east-west stretch of pastureland running from the Tunisian border to the Moroccan border between the 200 mm and 300 mm isohyets (cf. Map 5). The work was first carried out by the army and subsequently, from the mid-1980s onwards, by the forestry administration through state forestry enterprises. The Green Dam concept developed at the time into a set of agro-sylvo-pastoral measures in which the reafforestation component was predominant (86% of plantations) but more diversified as regards the choice of tree species.

The concept was abandoned in the early 1990s and then taken up again in the context of agricultural and rural development from 1995 onwards. The reafforestation measures were integrated into the national agricultural and rural development programme and combined with action to develop infrastructures and improve the incomes of the various population groups on a sustainable basis of market gardening, fodder crops and tree farming (cf. Table 4). The results obtained over thirty years are regarded as a failure: approximately 122,680 hectares have been reafforested, i.e. just over 10% of the acreage planned, and the success rate of these plantations is 36%. The clearing operations carried out with a view to monospecific reafforestation in the initial phase have adversely affected the environment and have disrupted the pastoral uses of these areas. At the economic level, on the other hand, the reafforestation activities have created seasonal jobs for steppe population groups. The failure of the Green Dam Project can be traced back to a variety of causes: incorrect implementation combined with lack of skills, high costs and poor cost-effectiveness. It was considered with hindsight, that it would have been more advisable to involve the users in measures to develop the steppes, to place knowledge and appropriate technologies at their disposal and to create incentive mechanisms (Bedrani, 1993).

Through the experience gained with the Algerian Green Dam Project more attention is gradually being devoted to the people of the steppes in the designing of efforts to combat desertification. The (2001-2003) programme of support for economic recovery included a component of anti-desertification action involving projects similar to those of the Green Dam Project of the 1990s.

Map 5 - The Green Dam Project in Algeria



Source: Bensaïd (1995).

Table 4 - Projects conducted within the national agricultural and rural development programme in Algeria, 2000-2007

	2000	**2007**
Aggregate number of jobs created by the end of 2007	142 300	1 161 000
Aggregate number of farms targeted by the end of 2007	0	431 000
Number of projects registered in the *Young Investors Scheme*	0	8 700
Aggregate acreage developed (ha of AAU)	37 900	585 000
Forest plantations carried out from 2000 to the end of 2007 (ha)	13 800	172 400
Pastoral plantations carried out from 2000 to the end of 2007 (ha)	72 471	218 500
Grazing bans at the end of 2007	1 447 400	1 975 000
	2001	**2007**
Measures to stimulate the economy and create services enterprises	2 226	22 240
Construction of tracks to open up areas (expressed in km)	2 347	9 000
Rural electrification (expressed in km)	615	2 000
Clearing of new tracks	-	8 000

Source: Ministry of Agriculture data (2008).

Fighting desertification in Tunisia – cross-cutting strategies, 1980-2006

The integrated rural development programmes that have been set up in Tunisia since the 1980s have contributed considerably to raising the living standards of the rural populations (Elloumi, 2006). These programmes (1986-1994 and 1994-2002) are sometimes referred to as integrated agricultural development schemes and are directed mainly at the poorest rural areas, which are labelled priority areas (the centre and west of the country in particular) and focus on developing infrastructures, promoting agriculture (incentive price policy during the initial period), crafts and trades and the services. This strategy has helped to reduce the urban-rural imbalance. The predominant socio-professional categories in rural areas always involve the lowest income levels, however (non-agricultural labourers followed by agricultural labourers and farmers) (Elloumi, 2006). The implementation of these programmes also brought an increase in the number of farms, which led to the reduction of the average acreage per farm and greater pressure on resources.

From the 1990s onwards, the second generation of projects laid emphasis on income-generating activities, action to promote rural women and the participation of target groups in the measures to identify development actions as well as in the financing and implementation of those actions. The Tunisian economy was then gradually liberalised and emphasis was laid on the competitiveness of production chains. In the same decade, the measures taken to implement national water and soil conservation strategies and strategies to mobilise water resources (1990-2000) endeavoured to combine action to promote agriculture with action to conserve natural resources. State intervention focused on environmental management interlinked with agriculture and on creating a favourable environment for producers (Elloumi, 2006). The declared objectives of the 10-year (1990-2000) forestry and pasture development strategy (Directorate General for Forests) and of the water and soil conservation and water mobilisation strategy (Directorate General for Water and Soil Conservation) were ambitious. The measures planned in each of these strategies[22] concerned over one million hectares, with implementation rates of approximately 45% (Rouchiche & Abid, 2003) and 65% (Helal *et al.*, 2007) respectively. The budget amounts actually allocated were in fact lower than the amounts originally planned (37% of the planned amounts in the case of forests), and the measures did not enjoy the same popularity everywhere. In particular, the rural communities opposed the plan to introduce forest tenure for land and collective rangelands. The Directorate General for Forests also elaborated a 10-year strategy to combat desertification over the period from 1990 to 2000, which focused on measures to halt sand encroachment;[23] the implementation rate is estimated at 71% (Rouchiche & Abid, 2003).

As regards development plans, the budgets planned for public investment in agriculture in the 9th, 10th and 11th plans (1997-2001, 2002-2006 and 2007-2011) do not have any

22 - In the case of the forest and pastureland development strategy, these are forest plantations, pastoral plantations and management of rangelands and pastoral reserves, and in the case of the water and soil conservation strategy: watershed works and cereal cropland development, water mobilisation units and works for combating silting and sand encroachment.

23 - Activities involve constructing and maintaining *tabias*, stabilising dunes and erecting tree belts and shelter belts as windbreaks. The budget for the strategy amounts to one-tenth of the budget finally committed in the forest and pastureland development strategy.

specific budget lines devoted to action to combat desertification (cf. Tables 5 and 6). Water schemes for agriculture were the main sector on which these plans focused on the whole, followed by forestry and water and soil conservation. The integrated agricultural development projects accounted for only 8% of investments in agriculture in the 10th plan, although this was already a 25% increase in budget compared to the 9th plan.[24]

Table 5 - Distribution of public investments in agriculture in the 9th and 10th development plans, Tunisia (in million dinars)

Activities	9th plan	10th plan (planned)	Variation (%)
Agricultural water schemes	1 072	1 206	+ 13
Animal farming	139	102	- 27
Fisheries	53	31	- 42
Studies, research and extension services	45	56	+ 24
Forests and rangelands	250	310	+ 24
Water and soil conservation	181	228	+ 26
Integrated agricultural development projects	124	216	+ 74
Miscellaneous	231	51	-
Total	**2 095**	**2 200**	**+ 5**

Source: Republic of Tunisia, Ministry of Agriculture (2002).

Table 6 - Trends in the share of the various activities in public investments in agriculture in the 10th and 11th development plans, Tunisia (in million dinars)

Activities	10th plan (implemented)	Share (%)	11th plan (planned)	Share (%)
Agricultural water schemes	1 014	51	1 242	56
Forests and rangelands	234	12	333	15
Water and soil conservation	238	12	229	10
Integrated agricultural development projects	167	8	169	7

24 - The activities involved in the integrated agricultural development projects and the corresponding amounts can be divided over the various budget lines, more specifically agricultural water schemes, agricultural mechanisation, crop growing, forests and rangelands, and water and soil conservation (Republic of Tunisia, Ministry of Agriculture, 2002).

Table 6 - (contd.)

Activities	10th plan (implemented)	Share (%)	11th plan (planned)	Share (%)
Fisheries	46	2	61	3
Animal farming	120	6	83	4
Studies, research and extension services	71	4	68	3
Crop production	4	-	33	1.5
Agricultural mechanisation	13	1	13	0.5
Miscellaneous	69	4	6	-
Total	**1 976**	**100**	**2 237**	**100**

Source: Republic of Tunisia, Ministry of Agriculture (2007).

These budget data clearly underline the fact that action to combat desertification in Tunisia cuts across many sectors and is perhaps a secondary concern. The trends observed indicate that anti-desertification measures are included in local development activities, particularly agriculture, and that the local population groups are involved to a greater extent. Although the integrated agricultural development projects and integrated rural development schemes certainly provide a basis for reconciling biophysical and socio-economic aspects at the local level, the biophysical approach of protecting soil against erosion is predominant in the efforts to fight desertification, as are the sectors traditionally in charge of protecting physical environments. And lastly, the question of biodiversity, which is closely connected with the desertification phenomenon, is not taken into account.

New models of participatory development in Morocco

The Moroccan national plan for fighting desertification that was drawn up in 1986 focused on two sectors, which were considered to be the priority: pastoralism and the supply of wood fuels. It was never implemented due to lack of funding, but was subsequently updated when the national action programme to combat desertification was being drawn up, and the principles of the 1999-2003 economic and social development plan were taken as a basis. The Report on the State of the Environment in Morocco (1999) lists the following performances:

- just over one-third of the objectives of the national reafforestation plan of the 1970s, which involved 662,000 hectares, had finally been achieved; the reafforestation masterplan which succeeded that plan made provision for reafforestation work involving 1.5 million hectares by 2025;
- the 1995 national plan for watershed management and the rangeland development strategy had resulted in measures to conserve water and soil on 440,000 hectares

(protective reafforestation, fruit plantations, pastoral and sylvo-pastoral improvement and development measures, mechanical gully treatment).[25]

As is illustrated by the distribution of public investments allocated to the economic and social development plan, the ratio between the agricultural sector and the forestry sector is 10 to 1 (cf. Table 7). As is the case in Tunisia, reafforestation and agricultural water schemes receive the most generous budget allocations.

Table 7 - Public investments involved in the Economic and Social Development Plan in Morocco, 2000-2004

Components	Amounts (million dirhams)
Forestry sub-sector	
Action to fight erosion	117 240
Afforestation	734 370
(Sylvo-pastoral) forest management	75 370
Forest estate management	154 760
Integrated development of urban and rural-urban forest areas	228 860
Biodiversity	124 150
Measures to strengthen research institutions	74 650
Subtotal	**1 509 400**
Agricultural sub-sector	
Large-scale water schemes	4 022
Small and medium-scale water schemes	3 163
Land improvement	59
Integrated agricultural development projects	2 285
Crop product chains	964
Animal product chains	599
Quality management	267
Training, research, extension services	1 216
Studies and information systems	112
Other actions (to boost investments, to economise water)	3 486
Subtotal	**16 173**

Source: National Action Plan to Combat Desertification, Morocco, 2001.

25 - The *National Report on the implementation of the Convention to Combat Desertification* (Morocco, report submitted to the Third Conference of the Parties, 1999) gives much higher estimates for these achievements.

In the Moroccan national action plan precedence is given to an approach integrating the various sectors traditionally in charge of protecting physical environments and the development sectors on the basis of the concept of participatory development, which can be achieved by promoting income-generating activities and developing microcredit to finance local investments. In 1995, the national watershed management plan made proposals for replacing the narrow concept of "watershed management" by a broader concept of "developing mountain areas" that would be based on small-scale schemes designed in a participatory approach and planned for the long term. And in its Strategy 2020 for rural development Morocco commits itself to fighting desertification as part of integrated rural development. However, although desertification is conceived as a phenomenon that cuts across many sectors and an issue of rural development in Morocco, it is not included in the National Report on the Millennium Development Goals (2003). The chapter on natural resources emphasises the energy question and biodiversity (reafforestation and protected areas indicator) and, in particular, water.

Protecting oases and reducing poverty

Oases are traditionally exploited at several levels in various ways (date palms, fruit trees, fodder, for example) and are also a focal point for animal farming (Bedrani & Chehat, 2005). They are a heritage of culture and biodiversity, which offer opportunities for tourism. This traditional exploitation of palm groves is being replaced by date palm monoculture, which is more profitable but also more harmful for the soil. The current irrigation race to develop these monocultures and greenhouse market gardening, which has a high value added, is causing groundwater depletion and soil salinity, which are contributing to the degradation of the oasis systems (OSS, 2008). Oasis tourism, which is undoubtedly a source of development, has in certain instances been a major contributing factor to the pressure on water resources (as is the case in the major Tunisian oases). The desertification of palm groves is thus generally the result of poor water resource management.

The measures to protect oases in the Maghreb that were included in action to fight desertification were limited initially to combating sand encroachment, after which other factors and realities began to be taken into account in the national action programmes. Measures were then taken to protect oases as part of the action to reduce poverty and combat desertification and to preserve heritages of culture and biodiversity. They targeted sites that were facing increasing prospects of poverty and abandonment.[26] In Morocco, the Directorate for Area Management drew up an oasis assessment and strategy document in 2004, which gave precedence to measures to rehabilitate and conserve these systems in the form of local participatory projects including anti-desertification action (cf. box entitled "Conserving and developing oases in the province of Tata, Morocco").

26 - It should be pointed out that some oases were created in the 20th century in order to settle the nomad populations or, later, for development experiments.

Conserving and developing oases in the province of Tata, Morocco

There has been serious degradation in Moroccan palm groves, which have lost almost three-quarters of their trees, and these losses have accelerated over the past 10 years (due to disease and overtapping of water resources). The populations of the oases in the south of the country in particular have seen their sources of income gradually diminish and as a result of this impoverishment have abandoned their oasis plantations and emigrated to the towns and cities.

Measures to conserve the oases are a fundamental component of the Moroccan strategy to combat desertification in the territories in the south of the country. The programme for developing the oases in the province of Tata pursues the objective of maintaining a viable and ecological exploitation system by restoring the agro-system in the oases and promoting local area development through four types of demonstrative action:

1. measures to economise/optimise the use of water resources in order to demonstrate in the areas where plots have been abandoned due to water shortage that it is still possible to develop agriculture there and thus keep the oasis alive;

2. measures to create economic value added with which date growers and their families can earn a living and thus improve their living standards and, in particular, stay in the oasis;

3. measures to consolidate the regional and associative structures that are currently the principal agents of local development;

4. ecological measures to restore the oasis ecosystem so as to regenerate and perpetuate the environmental framework for population groups that are subject to considerable natural constraints.

Source: (French) site of the United Nations Development Programme (UNDP, www.pnud.org.ma/P00050750.asp) in Morocco and of the Centre d'actions et de réalisations internationales (CARI, www.cariassociation.org/?section=programmes&subsection = oasis_maroc).

Social solutions

Local development and efforts to combat desertification

Local development involves the concepts of space and territory. In developed countries it is associated with area management and decentralisation; in developing countries it is based on action that mobilises local initiatives in small communities and amongst the inhabitants themselves, with external technical or financial aid as the case may be. The fight against desertification lends itself to this type of action and provides a basis for the concerted efforts of civil society, local authorities and scientists (Bied-Charreton & Réquier-Desjardins, 2007).

In the countries of the Maghreb, State administration has been decentralised as the result of structural adjustment programmes, and this has concentrated administrative structures in disadvantaged zones. At the same time reforms in Morocco and Algeria have facilitated the creation of associations, producer groups and cooperatives in an economic environment that is gradually being liberalised (Antonelli *et al.*, 2008). Local initiatives have flourished in this context in many different sectors, also in the zones

that had been "forgotten" by the administration, and international cooperation has supported this new form of social commitment.

This process has been particularly dynamic in Morocco for more than 10 years. Successful small-scale projects have emerged that combine human development and environmental protection, such as action to combat desertification and reduce poverty, for example, through the organisation of income-generating activities, and have gained momentum. They are geared to training, debate and the empowerment of users and they encourage the local people to think about local development; they also promote linkages with the local authorities, both contemporary and traditional (cf. box entitled "Involving local communities in action to preserve argan trees, Ibn Albaytar Association, Morocco").

Involving local communities in action to preserve argan trees, Ibn Albaytar Association, Morocco

The argan tree is a highly drought-resistant species, which is endemic to Morocco and grows in zones with an annual rainfall of 120 mm. Its presence prevents erosion and desertification. Its fruit contains nuts from which argan oil is extracted, a product which is recognised as having medicinal and cosmetic properties. These trees support some three million Moroccans. Argan oil extraction is developed in particular by rural women in disadvantaged arid zones.

The NGO Ibn Albaytar has been supporting these oil producers since 1996, helping them to set up production cooperatives, which operate the entire production chain from extraction to export. Five cooperatives have been established in five different provinces, and Ibn Albaytar provides training for the members in the organisation of cooperative activities and in the human development field in the form of modules covering technical aspects (extraction), legal aspects (how to form a cooperative), educational aspects (literacy training, health and environmental issues), management, and quality (traceability).

These cooperatives have now created a professional association (Economic Interest Grouping) in order to defend their interests more effectively, negotiate with other producers and define strategies with other actors in the industry with a view to improving the image of argan oil:

- they take part in the elaboration of standards and decrees (to promote quality);
- the oil they produce has gained international recognition (the Slow Food label) and has been certified by Ecocert as organically produced; ìt has also been awarded the "fair trade" label;
- they play a role in the development of their local communities, helping, for example, to promote tourism in the areas.

Source: Association Ibn Albaytar (www.association-ibnalbaytar.com).

In Tunisia, efforts to fight desertification are included in the objectives of the local development plans that are implemented by decentralised authorities. The actual participation of the local population in the measures to combat desertification in this context is often limited to the projects supported by international cooperation. It was encouraged, for example, in the implementation of the pilot project run by the European Union on "Strategies to combat desertification in arid lands with direct involvement of local agro-

pastoral communities". The final report on the integration of the participatory approach into this project as a central aspect proposes the following conclusions: "Although there are encouraging signs of mobilisation of local populations, there is still a great deal to be done to ensure that their action is effective. The producer structures and cooperatives are not yet in a position to manage their own affairs autonomously and the fledgling associations lack experience. […] The participatory process costs a great deal of time and effort, no matter what is said or done. There are no quick fixes, no ready-made answers. […] But the real opportunities for populations to participate always arise primarily at the local level. Discussions will no doubt be held in non-structured groups and at organised meetings. The official regional authorities have a crucial role to play and can help tremendously to promote cooperation and coordination amongst the various communities." (Bellal, 2007).

Socio-economic approach to desertification in southern Tunisia

Over and above the strategies for combating desertification and their implementation by the public authorities, rural societies are also developing solutions to the trends in their environment of which desertification is but one aspect. These solutions differ from one context to another (producer resources, economic environment, country and region). National policies for fighting desertification can be improved by taking them into account from the point of view of agricultural and local development, and this can promote further support for local initiatives.

In Tunisia, agriculture is still the primary activity in the rural world, and there is little diversification of incomes in rural areas on the whole. It is in the regions in the south of the country which are most affected by desertification that agriculture is most important. The Jeffara region (in southern Tunisia) has pre-desert features. Rainfall varies between 100 and 200 mm. The relief is diversified: watersheds, mountain ranges, foothills, and plains extending to the coast in the west. Human pressure on the natural resources of the region has been steadily increasing since the 1960s (Genin, 2006). The region has been gradually opening up for some time and has a long tradition of migration to the neighbouring towns and cities, regions and countries as well as emigration abroad (migrants move to the tourist resorts on the coast and to Tunis, Libya, or Europe) (Boubakri, 2006). The rural migratory balance is negative at the present time and the agricultural sector is in the throes of restructuring. Most farmers have several jobs, and agriculture has become a secondary activity in family incomes, although it provides a significant supplement, particularly in the form of food (Picouet & Sghaier, 2006; Genin *et al.*, 2006).

In the past, it was pastoral activities, the only activities in the plains, which governed how space was organised. Agriculture was concentrated on limited areas, where crops were grown using the rainwater and water run-off that was harvested along the watersheds or occasionally as rain-fed crops. Since the 1970s, far-reaching changes have come about in the uses of natural resources: irrigated agriculture has been extended down into the plains thanks to the use of groundwater resources, commercial crops have been developed, fruit trees and vegetables are now grown, and the pastoral sector has declined. Olive production, which is now practised by virtually all farms, is

predominant in both rain-fed and irrigated agriculture. Rain-fed agriculture is practised one year in two or three, depending on rainfall. This is a marginal form of agriculture, where the acreage used is limited and cereals are the predominant crop and are grown for family consumption.

Agricultural activities in the irrigated areas, most of which are State-owned and supplied with State-financed collective drilling, are geared to commercial crops for export, fruit trees, and vegetables (sometimes grown in greenhouses). Choices of this nature require high yields (price competitiveness) and efficient chain-type organisation for delivering produce to sales points (reducing transaction costs). As the result of the decline in sedentary animal farming on rangelands and the extension of agriculture, various systems of combined crop and animal farming have developed in the plains and in the hill country (Guillaume *et al.*, 2006). Animal farming practices have become less dependent on rangelands in general since they are more intensive and combined with fodder crop farming or involve the use of the available feed supplements. Exclusively pastoral animal farming involving large migratory flocks still exists. The development of private irrigated areas is slow due to the high cost of such investments – farmers can rarely afford them. If these private irrigated areas are to be economically successful they require a high level of technical expertise and equipment to produce yields that will make them profitable and allow them to be integrated into commercial exporting channels (Guillaume *et al.*, 2006).

The agricultural sector in this region is evolving towards a dichotomy between a limited number of large farms, which have benefited from the collective land privatisation policies and are based on the latest technologies, and a multitude of small family farms, whose produce simply helps to improve family income. A new category has emerged of wealthy farmers, who keep access to land for themselves and who have considerable investment capacities – for growing oil crops on large areas, for example, market garden crops in greenhouses, or fodder crops – and for developing sharp practices. Another (large) segment of the rural farm population is becoming impoverished, as is evidenced by the abandoned farms, the marked ageing of heads of household and the migration of the young generation. Outside the agricultural world the growing disparities have become accentuated between the interior of the country and the coastal area, which has been boosted by the development of the tourist and agro-food industries.

In this social landscape that is being recomposed desertification is not only connected with poverty but is also a hazard for the lands of the wealthiest farms practising intensive agriculture, including those that have high-tech irrigation. Thought should thus be devoted to agricultural production systems on a broader scale, including crop production systems, which are crucial to food supply in North African countries. Should anti-desertification action also take account of all of the related aspects and involve a more systematic approach to addressing non-agricultural economic activities and the relationship between urban and rural areas, for example from the point of view of employment, diversification and migration? These questions which arise again and again when one observes realities call for answers in public development and cooperation policies.

New strategy frameworks for fighting desertification

The countries of North Africa are facing far-reaching changes in both their natural resources and their environment, which are the result of both natural and anthropic factors such as the deterioration in climatic conditions, population growth and the increase in livestock, and the replacement of the traditional collective methods of managing space. Furthermore, the globalisation of the economy is encouraging people to adopt new consumption patterns and production methods in order to improve their living conditions. These factors mean that there is more pressure on natural resources, with serious consequences in ecological, economic and social terms. Faced with this situation, the bodies in charge of managing the environment and natural resources and of planning development must collect, manage and appropriately process the environmental data which describe natural environments and how they are being developed in order to subsequently disseminate reliable information on the state of the environment and on how those resources are being distributed and are evolving. This has become all the more necessary since by ratifying the international conventions on the environment these countries have undertaken to vest themselves with instruments for monitoring and evaluating action programmes as well as mechanisms for managing environmental data and information.

The Maghreb countries have considerably developed their approach to desertification over the past 10 years thanks to the process for preparing the UNCCD national action plans for combating desertification. They have promoted the coordination of multisectoral approaches and have integrated their programmes for fighting desertification into their rural development plans. The pace at which anti-desertification measures that are based on the lifestyles of rural societies and on local production system realities are developed differs from one country to another. In their efforts to establish monitoring and evaluation systems the institutional actors are gradually gearing their action to evaluating the cost-effectiveness of programmes for combating desertification on the basis of a multidisciplinary, multi-level and participatory approach, but they are meeting with operational difficulties. Although observation instruments and products do exist (thematic maps, satellite images, flora and fauna inventories, etc.) they vary widely from one country to another and are even disparate and often sectoral within individual countries. Despite the efforts of the Maghreb countries, performance levels vary and reveal the following shortcomings:

- the data that are generated in the context of one-off projects are inadequate for producing and updating information on a regular basis;
- the fact that maps on land use as well as certain statistical data are incomplete and/or obsolescent and that few such data are available is an obstacle to developing an integrated vision of desertification and rural development;
- the absence or scarcity of information on data (metadata) and the fact that the available information is not standardised (in terms of format and quality) are impeding the circulation, use and development of information.

This state of affairs is not conducive to the interpretation and cross-analysis of all bio-physical and socio-economic data, which would provide a basis for monitoring and evaluating the state of the environment (changes, trends, and so on), of habitats and their biodiversity, and of water resources and a means of identifying the causes (climate factors, anthropic factors such as the load capacity of ecosystems) and the consequences (water and wind erosion, salinisation, loss of arable land, etc.) in terms of resilience of natural environments. And lastly, knowledge is still inadequate as regards:

- the dynamics of agro-sylvo-pastoral production systems and the dynamics of local markets;
- human activities, agricultural practices and the impact on the natural environment in the peripheral regions to the north of those generally affected by desertification;
- population distribution and population trends as well as economic activities in the various regions.

Both decision-making instruments such as the network of monitoring and research stations which provide information for quantifying and evaluating the dynamics of environments and natural resources (degradation/regeneration) and for producing environment alert bulletins are also inadequately developed in a context where climate changes are worsening. The solutions that are advocated for remedying the most serious shortcomings in the information field are based on the establishment of synergy frameworks with a view first of all to strengthening communication amongst the various systems that exist and promoting the regular production and exchange of relevant information (indicators) as a source of input for the (current or future) performance charts to be used by the different users/policymakers at various levels.

In a context that is marked by growing liberalisation, the decline of agriculture as a source of wealth, growing insecurity for many farms in arid zones, increasing economic disparities, also in the rural world, and pressure on natural resources, it should be borne in mind that the agricultural produce of small farms is a fundamental complement to household income. It is in this context that action to combat desertification can be placed in order to enable and encourage rural populations to adjust to the major economic and environmental upheavals that have been taking place in the Maghreb for the last 10 years. These choices are matters of central policy, to be sure, but it is also to their advantage if they are guided by the decentralisation process, which enhances the participation of local authorities and civil society in local development and area management.

Bibliography

Abaab (A.), Bedrani (S.), Bourbouze (A.) & Chiche (J.), "Les politiques agricoles et la dynamique des systèmes agropastoraux au Maghreb", in M. Allaya (ed.), *Les Agricultures maghrébines à l'aube de l'an 2000*, Ciheam-IAMM, Montpellier, "Options méditerranéennes" collection, série B, 14, 1995.

Aidoud (A.) &Touffet (J.), "La régression de l'Alfa (*Stipa tenacissima*), graminées pérennes, un indicateur de désertification des steppes algériennes", *Sécheresse*, 7, 1996.

Aidoud, (A.) & Nedjraoui (D.), "The Steppes of Alfa (*Stipa tenacissima L.*) and their Utilisation by Sheep", in C. A. Thanos (ed.), *Plant-Animal Interactions in Mediterranean Type Ecosystems*, Medecos VI, Athens, 1992.

Antonelli (A.), Bessaoud (O.), Malorgio (G.) & Pugliese (P.), "La gouvernance des mondes ruraux et agricoles", in Ciheam, *Mediterra 2008. Les futurs agricoles et alimentaires en Méditerranée*, Presses de Sciences Po, Paris, 2008.

Aronson (J.), Floret (C.), Le Floc'h (E.), Ovalle (C.) & Pontanier (R.), "Restauration et réhabilitation des écosystèmes dégradés en zones arides et semi-arides. Le vocabulaire et les concepts" in R. Pontanier, A. M'Hiri, N. Akrimi, J. Aronson & E. Le Floc'h (ed.), *L'homme peut-il refaire ce qu'il a défait?*, John Libbey Eurotext, Paris, 1995.

Aubreville (A.), *Climat, forêts et désertification de l'Afrique tropicale*, Société d'éditions géographiques maritimes et coloniales, Paris, 1949.

Auclair (L.), Chaize-Auclair (M.), Delaitre (E.) & Sandron (F.), "Dynamique sociale et désertification: le cas de Menzel Habib dans le Sud Tunisien", *Acquis et perspectives pour un développement durable des zones arides*, international seminar, Jerba, 5-7 December 1996.

Auclair (L.) & Picouet (M.), "Dynamique démographique et utilisation des ressources: le cas de la Tunisie rurale", *Comptes rendus de l'Académie d'agriculture de France*, 8, 1994.

Bedrani (S.) & Chehat (F.), *Données agronomiques et socio-économiques sur la zone SASS en Algérie*, Rapport de projet SASS (Système aquifère du Sahara septentrional), OSS, 2005.

Bedrani (S.), "Les aspects socio-économiques et juridiques de la gestion des terres arides dans les pays méditerranéens", *Cahiers du Cread*, 1993.

Bellal (N.), *Rapport final sur l'intégration de l'approche participative dans le projet SMAP, Projet pilote sur les stratégies de lutte contre la désertification dans les régions arides avec implication directe des communautés agropastorales locales*, SMAP, European Union, 2007.

Ben Khatra (N.) & Essahli (W.), "Desertification Information System – Information System and Environmental Monitoring on Internet: Commentary and Outlooks", *Role of Information Circulation Systems in Scientific and Practical Approaches to Combat Desertification,* Proceedings of the AID-CCD Seminar, Windhoek and Ondangwa, Namibia, 2-7 April 2006.

Ben Ouezdou (H.) & Ben Kehia (H.), "Un long passé de valorisation des ressources en eau. Le cas du bassin-versant de l'oued Hallouf", in *Entre désertification et développement. La Jeffara tunisienne,* Tunis, Cérès éditions, IRD, IRAD, 2006.

Bensaïd (S.), "Bilan critique du barrage Vert", *Science et changements planétaires. Sécheresse*, 6 (3), 1995.

Bernus (E.), "Les causes de la désertification: les thèses en présence", *Bulletin de la Société languedocienne de géographie*, "La Sécheresse au Sahel", 18 (3-4), 1980.

Bied-Charreton (M.) & Requier-Desjardins (M.), "Sciences et sociétés civiles dans le cadre de la lutte contre la désertification", *Les Dossiers thématiques du CSFD*, 6, 2007.

Boubakri (H.), "L'autre face de la Jeffara: mobilité transfrontalière, migration internationale et dynamiques territoriales", in *Entre désertification et développement. La Jeffara tunisienne*, Tunis, Cérès éditions, IRD, IRAD, 2006.

Chaïeb (M.), Floret (C.) & Pontanier (R.), "Réhabilitation d'écosystèmes pastoraux de la zone aride tunisienne par réintroduction d'espèces locales", 4th International Rangeland Congress, Montpellier, 1991.

Cornet (A.), "La désertification à la croisée de l'environnement et du développement: un problème qui nous concerne", World Summit on Sustainable Development, Johannesburg, 2002.

Cornet (A.), "La désertification: un problème d'environnement, un problème de développement", conference, La Londe-les-Maures, 2000.

Dregne (H. E.) & Chou (N.-T.), *Global Desertification Dimensions and Costs. Degradation and Restoration of Arid Lands*, Texas Tech University, Lubbock (Texas), 1992.

Dregne (H. E.), "Combatting Desertification: Evaluation of Progress", *Environmental Conservation*, 11 (2), 1984.

Dregne (H.E.), "La désertification aux État-Unis d'Amérique", *Nature et ressources*, 13, 1977.

Elloumi (M.), "Les politiques de développement rural en Tunisie: acquis et perspectives", in J.-P. Chassany & J.-P. Pellissier (eds.), *Politiques de développement rural durable en Méditerranée dans le cadre de la politique de voisinage de l'Union européenne*, Ciheam-IAMM, Montpellier, "Options Méditerranéennes" collection, série A, 71, 2006.

Floret (Ch.), M'timet (A.M.) & Pontanier (R.), "Caractérisation écologique des régimes hydriques et de l'érodibilité des sols en zone aride", *Bases écologiques du développement rural intégré et lutte contre la désertification en zones arides et semi-arides*, Atelier interrégional Afrique/Amérique latine MAB-Unesco, *Terra arida*, 7, 1990.

Floret (C.) & Pontanier (R.), "L'aridité en Tunisie présaharienne: climat, sol, végétation et aménagement", *ORSTOM research and document,* 150, 1982.

Floret (C.), Le Floc'h (E.), Pontanier (R.) & Romane (F.), "Modèle écologique en vue de la planification et de l'aménagement agro-pastoral des régions arides: application à la région de Zougrata", *PNUE/CEPE/ORSTOM/IRA/DRES, Document technique*, 2, 1978.

Genin (D.), "Introduction", in *Entre désertification et développement. La Jeffara tunisienne*, Tunis, Cérès éditions, IRD, IRAD, 2006.

Genin (D.), "Élevages extensifs, environnements et systèmes de production en mutation en Tunisie rurale", Essai d'analyse à partir des données du programme DYPEN II. CNT, CREDIF, IRA, INRA, IRD, 2000.

Genin (D.), Hanafi (A.) & Cialdella (N.), "L'agriculture dans la Jeffara: entre permanence et bouleversements, quelle place dans la reproduction de systèmes sociaux?", in *Entre désertification et développement. La Jeffara tunisienne*, Tunis, Cérès éditions, IRD, IRAD, 2006.

Genin (D.), Guillaume (H.), Romagny (B.) & Sghaier (M.) *et al.*, "Du devenir de l'agropastoralisme à un développement multisectoriel régional: quelles perspectives?", dans *Entre désertification et développement. La Jeffara tunisienne*, Tunis, Cérès éditions, IRD, IRA, 2006.

Guillaume (H.), Genin (D.) & Nouri (H.), "Entre jessour, oliveraies et steppes: des dynamiques agro-territoriales en question", dans *Entre désertification et développement. La Jeffara tunisienne*, Tunis, Cérès éditions, IRD, IRA, 2006.

Hajjej (M.S.) & Ben Khatra (N.), "Articulation du dispositif de suivi-évaluation du PAN/LCD au processus de développement en Tunisie", *Suivi-évaluation des programmes d'action de lutte contre la désertification*, Tunis, OSS, 2006.

Hanafi (A.), *Cartographie des systèmes écologiques et étude de leur évolution depuis 1978 dans la région de Menzel Habib (Gabès)*, post-graduate diploma dissertation in geography, Tunis, FSHST, CNT, IRA, IRD, 2000.

Hanafi (A.) & Jauffret (S.), "Utilisation des données spatiales pour le suivi de la dynamique des écosystèmes dans le milieu aride tunisien. Cas de la région de Menzel Habib entre 1975 et 2000", *Revue française de photogrammétrie et de télédétection*, forthcoming.

Hanafi (M.) & Jauffret (S.), "Are long-term vegetation dynamics useful in monitoring and assessing desertication processes? A case study of arid southern Tunisian steppes", *Journal of Arid Environment*, 72, 2008.

Helal (S.), Mc Connel (R.) & Thirong (P.), *Relier les programmes forestier nationaux aux stratégies de réduction de la pauvreté, cas de la Tunisie*, FAO Forestry Department, FAO, Rome, 2007.

Hobbs (R. J.), Groves (R.), Hopper (S. D.), Lambeck (R. J.), Lamont (B. B.), Lavorel (S.), Main (A. R.), Majer (J. D.) & Saunders (D. A.), "Function of Biodiversity in Mediterranean Ecosystems in Australia", in G. W. Davis & D. M. Richardson (eds.), *The Function of Biodiversity in Mediterranean Ecosystems*, Berlin, Springer-Verlag, 1995.

Jaubert (R.), "Conclusion: exploitation des ressources, négociations et bureaucraties", dans R. Jaubert & B. Geyer (dir.), *Les Marges du croissant fertile, peuplements, exploitation et contrôle des ressources en Syrie du Nord*, Maison de l'Orient et de la Méditerranée, CNRS, Lyon, 2006.

Jaubert (R.), "La relance du plan d'action de lutte contre la désertification: les populations au centre des négociations", in C. Becker & P. Tersiguel (eds.), *Développement durable au Sahel*, Sociétés, Espaces, Temps, Karthala, Dakar/Paris, 1997.

Jauffret (S.), *Validation et comparaison de divers indicateurs des changements à long terme dans les écosystèmes méditerranéens arides. Application au suivi de la désertification dans le Sud tunisien*, doctoral thesis, Saint-Jérôme Faculty of Science and Technology, Aix-Marseille University (3), Marseille, 2001.

Laatiri (L.), "Projet SMAS. Mise en place d'un Système d'alerte précoce à la sécheresse en Algérie, au Maroc et en Tunisie. Activités réalisées par l'INM, Tunisie", communication presented at a regional workshop on drought early warning systems in the Maghreb, Algiers, 12-14 May 2008.

Le Floc'h (E.), Neffati (M.), Chaïb (M.) &Pontanier (R.), "Un essai de réhabilitation en zone aride. Le cas de Menzel habib (Tunisie)", in R. Pontanier, A. M'hiri, J. Aronson, N. Akrimi & E. Le Floc'h (dir.), *L'Homme peut-il refaire ce qu'il a défait?*, Libbey Eurotext, Paris, 1995.

Le Floc'h (E.), *Évolution de l'utilisation du sol et de la dégradation des milieux en Tunisie méridionale. Cas de la zone test de Zougrata. Projet "Parcours du Sud"*, provisional document, INRA Tunis, CEPE-CNRS Montpellier, 1976.

Le Houérou (H.-N.), *Les Pâturages naturels de la Tunisie aride et désertique*, Institut des sciences économiques appliquées, Paris, Tunis, 1962.

Le Houérou (H.-N.), "La désertisation du Sahara septentrional et des steppes limitrophes", *Annales algériennes de géographie*, 6, 1968.

Le Houérou (H.-N.), "La végétation de la Tunisie steppique", *Annales INRAT*, 42 (5), 1969.

Le Houérou (H.-N.), "Biological Recovery Versus Desertization", in D. L. Johnson (ed.) "The Human Face of Desertification", *Economic Geography*, 53 (4), 1977.

Le Houérou (H.-N.), *Bioclimatologie et biogéographie des steppes arides du Nord de l'Afrique. Diversité biologique, développement durable et désertisation*, Ciheam-IAMM, Montpellier, "Options méditerranéennes" collection, série B, 10, 1995.

Le Houérou (H.-N.), "Biogeography of the Arid Steppeland North of the Sahara", *Journal of Arid Environments*, 48, 2001.

Loireau (M.), Sghaier (M.), Fétoui (M.), Ba (M.), Abdelrazik (M.), d'Herbès (J-M.), Desconnets (J-C.), Leibovoci (D.), Debard (S.) & Delaître (E.), "Système d'information à l'échelle locale (Siel) pour évaluer le risque de désertification: situations comparées circum-sahariennes", *Science et changements planétaires. Sécheresse*, 18 (4), 2008.

Loireau (M.), *Espaces-Ressources-Usages: Spatialisation des interactions dynamiques entre les systèmes sociaux et les systèmes écologiques au Sahel nigérien*, doctoral thesis, Department of Geography, Montpellier University (3), Montpellier, 1998.

Mainguet (M.), "Désertification: Quels sont les vrais problèmes?", *L'Information géographique*, 58, 1994.

Meckelein (W.), "T he problem of desertification within deserts. An introduction and several conclusions", in W. Meckelein (ed.), *Desertification in Extremely Arid Environments*, Stuttgart, Geographisches Institut der Universität, 1980.

Milton (S. J.), Dean (W. R. J.), du Plessis (M. A.) & Siegfried (W. R.), "Conceptual Model of Arid Rangeland Degradation. The Escalating Cost of Declining Productivity", *Bioscience*, 44 (2), 1994.

Nasri (S.), *Systèmes agraires et organisations spatiales en milieu aride: cas d'El Ferch et du Dahar de Chenini-Guermessa (Sud-Est tunisien)*, doctoral thesis, Paul Valéry University Montpellier (3), 2002.

OECD, *Environmental Indicateurs*, Paris, 1994.

OSS, *The North-Western Sahara Aquifer System: Concerted management of a transboundary water basin,* "Synthesis" Collection No. 1., OSS, Tunis, *2008.*

OSS (coord.), *The monitoring and evaluation of National Action Programmes to Combat Desertification,* OSS, Tunis, 2007.

OSS, *Concepts et approche méthodologique d'élaboration des outils du suivi-évaluation du PAN/LCD. Application au cas de la Tunisie*, report on the Tunisia-Italy project, 2004.

OSS-CEN-SAD, *The Great Green Wall Initiative of the Sahara and the Sahel*, Intoductory Note No 3, OSS, Tunis, 2008.

Ouessar (M), Yahyaoui (H.), Ouled Belgacem (A) & Boufalgha (M.), "Aménagement et techniques de lutte contre la désertification: inventaire et bilan", in *Entre désertification et développement. La Jeffara tunisienne*, Cérès éditions, IRD, IRA, Tunis, 2006.

People's Democratic Republic of Algeria, *National action plan for environment and sustainable development (NAPE-SD)*, Metap, 2002.

People's Democratic Republic of Algeria, *National action programme to combat desertification*, Ministry of Agriculture and Rural Development, Directorate-General for Forestry, 2004.

Pieri, (C.), Dumanski, (J.), Hamblin (A.) & Young (A.), "Land Quality Indicators", World Bank Discussion Papers, WDP 75, 1995.

Picouet (M.) & Sghaier (M.), "Dynamiques socio-démographiques et pluriactivité", in *Entre désertification et développement. La Jeffara tunisienne*, Cérès éditions, IRD, IRA, Tunis, 2006.

Quézel (P.), Médail (F.), Loisel (R.) & Barbero (M.), "Biodiversity and Conservation of Forest Species in the Mediterranean Basin", *Unasylva*, 197, *Mediterranean Forests*, 50 (2), 1999.

Requier-Desjardins (M.) & Bied-Charreton (M.), *Évaluation économique des coûts économiques et sociaux de la désertification en Afrique*, AFD, Paris, 2006.

Republic of Tunisia, Ministry of the Environment and Area Management, *National action programme to combat desertification*, 1998.

Republic of Tunisia, Ministry of Agriculture, *11th Development Plan (2007-2011)*, 2007.

Republic of Tunisia, Ministry of Agriculture, *10th Development Plan (2002-2006)*, 2002.

ROSELT/Algérie, *Observatoire des hautes plaines steppiques. Bilan final du projet ROSELT/OSS (2002-2005)*, USTHB-CRSTRA, 2005.

ROSELT/OSS, *Conception, organisation et mise en œuvre de Roselt/OSS*, coordination régionale Roselt, Montpellier, IARE, 1995.

Rouchiche (S.) & Abid (H.), *Role of Planted Forests and Trees Outside Forests in Sustainable Forest Management: Republic of Tunisia - Country Case Study*, working paper FP/27F, FAO Forestry Department, FAO, Rome, 2003.

Kingdom of Morocco, *National action programme to combat desertification*, Ministry of Agriculture, Rural Development, Water and Forests, 2001.

Kingdom of Morocco, Directorate for Observation, Studies and Coordination, *Report on the State of the Environment in Morocco*, Chapter 2: "Physical Milieu", 1999.

Sarraf (M.), Larsen (B.) & Owaygen (M.), *Cost of Environmental Degradation, the Case of Lebanon and Tunisia*, World Bank, Metap, Environmental Economic Series, Paper 57, 2004.

Secretariat-General of the MAU, *Programme d'action sous-régional contre la désertification au Maghreb*, MAU, 1999.

Sghaier (M.), Fetoui (M.) & Tbib (A.), "Contribution à l'analyse des évolutions des systèmes "population-exploitation des ressources naturelles" dans l'observatoire de Menzel Habib (Sud-Est tunisien)", *Science et changements planétaires. Sécheresse*, 18 (4), 2008.

Sghaier (M.), Ben Abed (M.A.), Fetoui (M.), Bennour (L.) & Jaouad (M.), *Système d'information sur l'environnement à l'échelle locale (SIEL): cas de l'observatoire de Menzel Habib et installation de MDweb (Tunisie)*, Scientific report of the ROSELT/OSS programme, 2006.

Sghaier (M.), Mahdhi (N.), De Graaff (J.) & Ouessar (M.), "Economic Evaluation of Water Harvesting at Catchment's Scale: An Application of the Forces MOD Model", in J. De Graaff & M. Ouessar (eds.), *Water Harvesting in Mediterranean Zones: An Impact Assessment and Economic Evaluation*, TRMP Paper 40, Wageningen University, Wageningen (Netherlands), 2002.

Skouri (M.), "Desertification in the Mediterranean Basin: Present State and Future Trends", *The Situation of Agriculture in Mediterranean Countries*, "Options méditerranéennes" collection, 1, Ciheam MAI, Zaragoza, 1993.

UNCCD, *Benchmarks and Indicators for Monitoring and Assessment of Desertification*, Report of the Fifth Meeting of the Group of Experts of the Committee on Science and Technology, Addendum, Committee on Science and Technology, session 8, "Conference of the Parties", ICCD/COP (8)/CST/2/Add.1, Madrid, 4-6 September 2007.

UNCCD, *National reporting process of affected country parties,* explanatory note and help guide, ICCD/CRIC (3)/INF3, Bonn, May 2003.

UNCCD, *United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa*, text with annexes published by the Secretariat of the Convention, Bonn (Germany), 1994.

UNEP, *Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification*, Nairobi, Report of the Executive Director, 1991.

Wakrim (M.), "Monitoring-evaluation, a tool for sustainable management of natural resources and combating desertification", in *The monitoring and evaluation of national action programmes to combat desertification*, 2006.

World Bank, *Agriculture for development*, World Development Report, 2008.

World Bank, *Arab Republic of Egypt: Cost Assessment of Environmental Degradation*, Metap, 2002.

World Bank, *Kingdom of Morocco*: *Cost Assessment of Environmental Degradation*, Metap, 2003.

Yassin (M.), Mandouri (T.), Oudadda (A.), El Ouadi (M.), Taleb (M.S.), Hanane (S.), Ramdane (A.), Benidir (M.), Hammoudou (M.) & Belayachi (K.), *Deuxième Rapport de surveillance de l'observatoire Roselt/OSS de l'Oued Mird*, HCEFLCD, Morocco, 2005.

Annex

Annex 1 – The indicators selected by Morocco for monitoring and evaluating the national action plans

Reducing poverty

- Population growth rate
- Proportion of rural population in the total population
- Per capita GDP
- Illiteracy rate
- Share of the employed rural labour force working in the agriculture, forestry and fisheries sector
- Gross (primary) enrolment ratio
- Percentage of rural households connected to the drinking water mains
- Percentage of rural households with electricity
- Poverty rate
- Rural unemployment rate

Water resources

- Volume of surface water mobilised
- Volume of groundwater mobilised
- Rate of water resource mobilisation
- Per capita volume of water available
- Dam filling rate (September)
- General water quality indicator
- Dam reservoir silting rate

Forest areas

- Forest area
- Reafforested area
- Regenerated area
- Approved delimited forest area
- Area treated against water erosion
- Area of stabilised dunes
- Acreage of protected areas that have been developed

- Gutted area
- Cleared area
- Degraded forest area

Rangelands

- Trends in small ruminant stock
- Number of animal watering points
- Share of developed rangeland
- Land used for rain-fed agriculture
- Share of the AAU that is annually under crop
- Share of the AAU that is annually under fallow
- Share of the total mechanized acreage that is treated with cover crop
- Acreages of the main crops (crop rotation)
- Total area of tree plantations
- Area planted annually within the framework of the National Plant Oil Production Plan
- Annual outputs of the main crops
- Annual irrigated crop acreages
- Share of irrigated crop acreages that are extremely "water-greedy"
- Quantities of fertilisers and pesticides used annually
- Yields and outputs of the main irrigated crops

Land used for irrigated agriculture

- Volume of water consumed by irrigation
- Area of irrigated farmland
- Developed areas
- Recovery rate of water charges

Oases

- Number of seedlings distributed in the context of the national plan for restructuring and rehabilitating palm groves

General indicators

- Vegetation index (NDVI)
- Surface temperature (ST)