Desertification and its relationship to the environment and development: a problem that affects us all.

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Introduction.

There is a wide variety of terms used to describe desertification and its expansion across geographical space which no doubt stems from attempts to attract increased resources to combat the phenomenon. Unfortunately, by extending the concept, its meaning has been weakened, resulting in the opposite of what was intended. A clear notion of desertification is essential so that it may be applied diagnostically and operationally as a value.

Monitoring and assessment of desertification both have dual objectives. Firstly they measure and evaluate the degree of land degradation in order to diagnose the seriousness of the problem. And secondly they measure the impact of action undertaken. They rely on in-depth knowledge of the mechanisms and processes involved, and on the development of specific tools, such as indicators and observatories.

Desertification is both an environmental and developmental problem. It affects local environments and populations' ways of life. Its effects, however, have more global ramifications concerning biodiversity, climatic change and water resources. The degradation of terrain is directly linked to human activity and constitutes both one of the consequences of poor development and a major obstacle to the sustained development of dryland zones. Beyond the application of appropriate techniques, efforts to combat desertification should be accompanied by measures to stimulate economic and social change and should also be an integral part of development programs.

The United Nations Convention to combat desertification indeed expresses a change of direction in this respect. Its founding objective is to encourage governments to undertake commitments at State level or in terms of aid to development so as to define legislative and statutory frameworks that will enable populations to plan and manage their own natural resources. Where the convention has been less effective, is in the setting up of specific development tools such as funding mechanisms or tools that effectively incorporate science and technology into their processes. It has nevertheless lead to real progress, particularly concerning the mobilisation of human resources. Its future and its implementation will depend on the parties involved and their ability to find swift partnership solutions.

The notion of desertification.

From the origins of the term to international awareness.

In the accepted meaning and dictionary definition of the term, desertification involves the transformation of a region into desert. The primary meaning of "desert" is an area devoid of human presence. Today, by extension, the term has taken on a climatic and biological dimension encompassing regions with scarce or irregular rainfall or those with sparse or reduced vegetation. Various

different definitions of desertification have been proposed over time, in particular in the last twenty years. The abundance of definitions possibly conceals the impreciseness of the concept while different scientific or political communities have brought different acceptances and interests to the term.

In 1927, describing the impoverishment and deterioration of the southern Tunisian forests, in a paper entitled "Les forêts du Sahara," Louis Lavauden seems to have been the first to have given the term "desertification" a scientific meaning. He attributes an anthropogenic origin to the phenomenon: "In the whole of the zone in question, desertification, if I may so say, is a purely artificial phenomenon. It is a purely man-made occurrence. It is also a relatively recent event and could be combated and eradicated." Fairfield Osborn, in 1948, in his work *Our Plundered Planet* denounces the deterioration of the planet's natural resources through human action as the most important problem in the world concerning the future of man. Observing the deterioration in vegetation and soil in the sub-humid north of Central Africa, Aubreville wrote in 1949: "What we are seeing are actual deserts emerging before our eyes, in countries where the annual rainfall is 700 to 1500mm of rain."

In the fifties, the Unesco arid zone research program brought developments from the scientific community and our knowledge about ecology to bear on such environments. However, the connections between human activity and the dynamics of regions remained practically unexamined. The serious drought that affected the Sahel in the seventies, along with famine, social crises and influxes of refugees, called international attention to the environmental crisis in hand and the problems of the development of dryland zones in a dramatic way.

The United Nations organised a conference on the Human Environment in 1972. The government and international communities formed an inter-state committee to control drought in the Sahel (the Cilss). The United Nations Sahel Office (the Unso) was also created within the Pnud. The United Nations General Assembly decided to hold a conference on desertification in Nairobi in 1977, the Uncod (United Nations Conference on Desertification). The conference proposed the following definition of the term: "Desertification means the reduction or destruction of the biological potential of a region and may eventually lead to the emergence of desert conditions. It is one aspect of the general degradation of ecosystems." It laid down a plan of action to combat desertification (the Padc) with 28 recommendations detailing courses of action to be undertaken. It entrusted the implementation and the follow-up of the plan to the "United Nations Environment Program" (Unep). There then followed a phase of international research initiatives and the setting up of international loans and intervention schemes, particularly concerning reforestation.

During this period, the term "desertification" was at the centre of much debate and controversy and it is worth remembering a few points emerging from it: land degradation became distinguishable from drought, a term that designated the consequences of a more or less prolonged deficit in water. Drought was seen as a factor that made desertification worse. The use of the term desertification in the expression "desertification of rural areas" seemed to derive from the idea of an area becoming "deserted," that is to say, uninhabited. In this case, desertion would be more appropriate

Le Houérou, based his work on land research studies and, in 1968, created the term "desertisation." The term, with its scientific content, was meant to be more specific but was not retained by the international community. In 1991, the UNEP formed an ad hoc group to provide a "global evaluation of desertification – conditions and methods." According to the proposed definition, desertification was "land degradation in arid, semi-arid and sub-humid zones resulting primarily from human activity. It involves a certain number of processes which lead to the impoverishment of soil quality and vegetation where human activity is the main factor." The definition recognises humankind's own detrimental impact as the primary cause of desertification. Included in the notion of land degradation are declining harvests, reduction in vegetation cover, the way that physical mechanisms harm the surface of the ground, the reduction in quantity and quality of water resources, and the deterioration of soil quality. The definition featured a geographical dimension – desertification concerned land without water or areas corresponding to arid, semi-arid and sub-humid dryland zones. This refers to the definition of bioclimatic zones based on the value of the P/Etp ratio (the relation between total annual rainfall and the annual value of potential evapo-transpiration). Dryland zones under consideration thus corresponded to a ratio of $0.05 < P/Etp < 0.65$ (UNEP, 1992, in Le Houérou, 1995). Highly arid zones ($P/Etp < 0.05$) were not taken into account as they were already considered to be desert.

Following requests by the countries affected, desertification was put at the top of the agenda at the United Nations Conference on Environment and Development in Rio in 1992 (UNCED). The international community recognized that desertification was a global environmental problem which required a worldwide response. The Conference asked the United Nations Assembly to instigate an intergovernmental negotiation committee to draw up a Convention to combat desertification. In accordance with the established schedule, the committee completed negotiations and the United Nations Convention to combat desertification was adopted in Paris on 17 June 1994. It was ratified in 1996 by more than 50 countries and came into effect in December of the same year. The definition of desertification retained at

international level – and first stated in chapter XII of Agenda 21 reads: "Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities." (Article 1). This definition is the result of a political compromise between the various parties and, although it retains the same geographical dimensions, it differs in significant ways to the preceding definition, in particular as far as highlighting causal factors is concerned. It effectively reduces the previous emphasis on human agency as central to the process of degradation.

Beyond words, concepts and clarity.

The term "desertification" has been the subject of much discussion and even controversy, in the course of which it has been defined in many different ways. It is however crucial to be clear about the notion and give its content both diagnostic and operational dimensions. According to Glantz and Orlovsky (1983), there were nearly 100 definitions in circulation in the eighties. Katyal and Vlek, in a recent study (2000), collated criteria included in definitions by different authors so as to highlight areas of agreement and disagreement. They observe that desert expansion theory, defended in particular by Lamprey (1975), which evaluated the advance of the Sahara at 5.5 km a year, has been rejected by the scientific community. Various studies have conclusively shown that deserts were not showing significant advance (Warren and Agnew, 1988). Instead, recent studies based on spatial observation show that desert frontiers either advance or recede according to the rainfall of a given year (Tucker et al., 1991). Likewise, a consensus has been reached to the effect that land desertification concerns dryland zones, i.e. arid, semi-arid and dry sub-humid zones that correspond to a ratio of $0.05 < P/Etp < 0.65$ (UNEP, 1992). Hyper-arid zones ($P/Etp < 0.05$) are not taken into account. Likewise, the land degradation in humid zones, often linked to deforestation, is considered separately.

Among the differences of opinion, there are several major points to remember, even if our knowledge today enables us to provide certain nuances:

1 Does the term desertification describe a process or the condition of an area?

2 Is desertification a reversible or irreversible phenomenon?

3 What are the respective roles of human agency and climatic conditions in desertification?

For certain authors (Rapp, 1974; Ahmed and Kassas, 1987; Mainguet, 1994; etc) "desertification" corresponds to the state of an environment that manifests desert-like conditions, in the final stages of land degradation. Others (Rozanov, 1982; Dregne and Chou, 1993; etc) consider that the term

"desertification" describes processes of degradation to soil quality and vegetation, processes that can be either reversible or not, and that bring about a gradual loss in productivity. These two points of view are significant in two respects, firstly in the evaluation of the extent of the problem. Effectively, the zones affected by desert conditions represent only a small part of arid zones in general, whereas vast spaces are affected by the degradation of natural resources. Secondly, differences in opinion here influence strategies and whether priority should be given to restoration of damaged zones or to eliminating causes and implementing preventative measures. Land degradation is a major problem for the environment and in the development of dryland zones. It is from this viewpoint that international authorities (UNEP, UNCED) have retained the term "desertification" to refer to land degradation in dryland zones. This definition does not quantify the degree of land degradation that should characterise desertification. Some authors such as Katyal and Vlek (2000) suggest that areas affected by productivity losses of more than 15% be considered to be in the process of desertification, but provide no means to measure this.

Land degradation covers a wide variety of processes, implying various degrees of seriousness. Many authors associate desertification with criteria governing irreversible degradation (Le Houérou, 1968, 1992; Rozanov, 1982; Mainguet, 1995). When talking of desertification, the term "irreversible" is used when vegetation and soil have no chance of returning to their original state despite the total or almost total protection of an area for the duration of one generation, or twenty-five years (Floret and Pontanier, 1982). According to Warren and Agnew (1988), land degradation includes desertification, which is an extreme manifestation of it. Desertification, limited to only arid zones, is considered as the final stage of degradation of natural and exploited ecosystems. According to Le Floc'h (1996), The notion of an "irreversibility threshold" enables differentiation between these two notions. Desertification associated with a total loss of productivity and resilience is not a sudden phenomenon. On the contrary, it appears as an evolutionary process, marked, of course, by different thresholds. The gradual insidious process of land degradation leads to irreversible desertification. If, on the scientific level, it is wise to fix evolutionary and irreversibility thresholds within the process, on the applied level, land degradation is certainly a more common occurrence and constitutes a greater, more serious threat to the maintenance of land use and its ecological functions. However, were the concept of desertification to include the notion of irreversibility as the ultimate stage in a series of processes leading to a definitively sterile environment, in our current technological and economic context it would be rarely employable. According to Dregne (1983), only 0.2 % of the terrain of our planet would be affected. Any evaluation of

the affected zones should include notions of the different degrees of degradation, even when the process is reversible.

Generally, all authors are in agreement that desertification is mainly caused by human intervention. Land degradation occurs when natural balances or dynamics are altered by human agency through over-exploitation of resources. Human actions are largely voluntary; sometimes they are linked to ignorance, but often they are determined by increases in demand in contexts where technology has evolved insufficiently and rules governing access to resources are absent. If human agency is undeniable and widely demonstrated, climatic conditions also have an impact and their respective roles are discussed extensively. Droughts, in particular in the Sahel, have shown up the desertification of these zones. Reduced rainfall, or its wider variability, has increased natural resources' vulnerability to degradation and it is less easy for ecological and social systems to resist. However, it has been observed that the impact of such droughts is weak or negligible where human or animal impact is low or non-existent (Le Houérou, 1993). Indeed, the vegetation and soil of arid regions have been able to adapt to recurrent drought conditions over the past centuries and millennia, acquiring an ability to recover their characteristics if disturbed (what is known as "resilience"). According to Le Floc'h (1996), the most serious ecological problems stem from the behaviour of populations or actions carried out during climatically favourable periods and their consequences only appear afterwards, when degradation has lead to a loss of resilience and recovery capabilities following disturbances. Drought in this instance can reveal existing degradation. All authors concur that a rise in drought phenomena does not cause desertification but is an important factor concerning the enhancement of anthropogenic effects on land degradation in dry-land areas.

The causes and processes of land degradation.

The notion of "land" refers to the natural components of cultivated or non-cultivated ecosystems. It includes various elements – the earth, the water, vegetation, fauna, physiography and microclimate – that may be described in terms of biophysical characteristics or attributes. Land serves various purposes for man – for agriculture, forestry, pasture, and as a support for infrastructures. Land also plays a regulating role in ecological and environmental terms. Land degradation means the loss of certain inherent properties or the reduction of their capacity to fulfil essential biological, ecological, economic or social functions. Such degradation is associated with the degradation of their constituents or of their functional links.

Human activities are determined by social context and by economic and institutional environment. They are translated into concrete actions

on the environment via practices that modify biophysical processes and ecological characteristics. The growth in populations' needs and the absence or obsolescence of rules governing access to resources leads to an increase in pressure on resources and to badly adapted and harmful practices. Such practices – like overgrazing, extensive clearing and deforestation – have an effect on vegetative cover and soil. They modify the biophysical functioning processes of agronomic and ecological systems leading to a series of repercussions that may engender a spiral of degradation. The halting or modification of such practices produces different evolutionary trajectories and possible recovery if irreversibility thresholds have not been reached.

In general, degradation starts with an alteration of vegetation, modification of flora constituents, and species most sought after or used become rarer or disappear. Then, or simultaneously, vegetative cover becomes thinner and the production of biomass diminishes. Capacities for reproduction and regeneration of vegetation reduce further. Soil loses protection from vegetation and is open to the mechanical action of rainfall which causes a change in the state of its surface. The biomass reduces and thins out leading to progressive loss of organic matter, one of the determining constituent elements of soil properties. Structural stability and porosity decrease, while

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Conceptual framework of the causes of desertification and land degradation.

Signs
Destruction of plant cover, lowering in land productivity, erosion of the soil and transformation to sand

Immediate causes
Overgrazing, inappropriate cultivation, excessive extraction

Underlying causes
Increase of human pressure, poorly adapted techniques and management methods, drought and climatic accidents, ecosystem fragility

Fundamental causes
Demographic increase, poorly adapted control of access to resources, economic crises, poverty, institutional frameworks and development decisions

openness to erosion increases leading to progressive destruction of the ground. The consequences on fertility – lowering of exchange capacity and of available elements – and on hydric elements – increase in runoff, lowering of supplies of water available to plants, modification of the hydric regime and exchanges with the atmosphere, and aridification – are highly significant. These consequences will have an effect on vegetation and production. Degradation starts a downward spiral and without intervention will lead to irreversible desertification.

Desertification and land degradation described here in general terms result from interactive and complex processes, driven by a number of factors that work on different scales in both time and space. If desertification is indeed a global phenomenon affecting dryland zones in general, on a local scale situations and developments are diverse and correspond to original combinations of factors. This means that in order to take action against desertification, there is a need for reliable data governing the state of the local environment, which incorporates and identifies the respective interests of the different types of actor in the zone.

The result of land degradation is the progressive loss of vegetation and soil productivity in dryland zones, leading to a weakening of productive capacities and abilities to sustain the populations living there. It means that ecological systems, as well as alternative practices, have little possibility to develop. In advanced stages of degradation, land becomes unfertile, whole zones stripped of plant life and their populations abandon them. Beyond consequences on a local scale, desertification may have more far-reaching effects, with serious economic and environmental consequences. The erosion of soil and shifting sands means sand is introduced into neighbouring areas, infrastructures, sometimes even towns. The degradation of water reservoirs in areas of relief leads to problems of water level, flooding and damming. Finally, the destruction of living conditions and of populations' resources accelerates and aggravates migratory problems. Desertification constitutes the main obstacle to sustainable development in dryland zones.

Assessment and monitoring of desertification.

The extension and increase in cases of land degradation coupled with concerns voiced by both those countries concerned and the international community have created the need to perfect evaluation and surveillance tools. The establishment of categories and rates of land degradation (Warren and Agnew, 1988), however, presents a certain number of problems concerning:

1 the nature of the criteria to be retained to measure the state of degradation;

2 the evaluation of resilience and the soil's recovery capacities;

3 how to incorporate fluctuations between years and variability;
4 the availability of necessary data;

the relation between data and the criteria implemented and the capacities for the maintenance of local land use systems. In the authors' minds, criteria used to evaluate tendencies of land degradation and desertification should be clear, relevant and specific, both in terms of environment and scale, which supposes prior knowledge of fundamental processes.

The objectives pursued in desertification assessment-monitoring are twofold – firstly to evaluate and measure the state of land degradation so as to diagnose the seriousness of the problem, to characterise its scope and detect changes and evolution. Secondly, to gauge the performance of countermeasures and action undertaken as well as the effects of national political decisions in this domain. The need for evaluation and monitoring is expressed in the desertification convention which obliges countries to report advances in countermeasure application. There are a number of articles that deal with data collection and the establishment of indicators.

Several sources provide data about desertification tendencies, ranging from global surveys and analyses of satellite data to studies of local level environmental change. Global data about desertification has emerged from two main sources: firstly, from the Global Assessment of Soil Degradation (Glasod), carried out at the University of Wageningen for the Fao. Data is presented to a scale of 1/10 000 000th. Secondly from the International Centre for Arid and Semi-Arid Land Studies (Icasals) of the Texas Tech. University; this data refers to soil degradation in zones suffering from degradation of vegetation. Generally, figures supplied by Icasals are much higher than those from Glasod. The estimation of the percentage of arid land on the planet suffering from desertification varies from between 19.5 % (Glasod) to 69.5 % (Icasals) depending on the sources. The Unep itself recognises that the data used to establish an Atlas of desertification, published in 1992, was incomplete and imprecise. Whilst it did not deny the importance of the problem, it concluded that more detailed and better quality information was required urgently.

Furthermore there are detailed case studies that have enabled us to come to a good understanding of environmental change and the way populations react in a given place. Such local-level studies, often carried out over a number of years, demonstrate the resilience of grazing and farming systems to large-scale variations of rainfall (Toulmin, 1993). This research presents a very different picture to research on a more global scale. The main problems here arise from using studies of a limited number of sites to draw more general conclusions about whole regions and from reconciling often contradictory results obtained at a local level with those obtained at a global level.

What means and methods do researchers have available to evaluate and monitor the progress of desertification?

Desertification and land degradation result from mechanisms and processes that are both complex and interactive and that depend on a whole range of factors effective at different times and places in different ways. Monitoring them requires details of the biophysical and socio-economic conditions of environments undergoing such phenomena but also an understanding of the mechanisms and processes resulting from these conditions. Furthermore, monitoring requires the establishment of basic parameters in order to define effectively the conditions of the environment and their dynamic relationship in space and time. Then, the interactions between those factors inducing desertification-related processes need to be analysed and modelled. Without going into every aspect with its own research concern, we will briefly touch on three: indicators, observatories and monitoring from space.

Indicators.

Indicators are traditionally used in evaluation, monitoring, and forecasting because they translate processes, situations and their evolution in a summarised form. As with many other terms, "indicator" has a very broad use and it is worth reminding ourselves of several definitions.

Definition of terms.

Indicator
Parameter or value calculated on the basis of other parameters, giving indications about or describing the state of a phenomenon in the environment or in a particular geographical area, and whose scope is broader than the information directly linked to the value of a normal parameter.

Index
Group of weighted or aggregated parameters or indicators describing a particular situation.

Parameter
Measured or observed characteristic or property.

Benchmark
A benchmark is a norm in relation to which indicators or indices can be compared with a view to determining trends.

Indicators have, according to the OCDE (1993), two main functions:

1 to reduce the number of measurements and parameters that would normally be needed for the precise assessment of a situation.

2 to simplify the process of communicating results of measurements to users.

Their aim is to condense a large amount of information into a few understandable measurements, then to help us decide what action to undertake. To do this, indicators have to be correlated to aims and objectives and expressed in terms compatible with these aims and objectives. A good indicator should be relevant to the problem in hand, based on reliable data and analysis, and respond to user needs. It should be sufficiently sensitive to indicate changes early on. (Rubio and Bochet, 1998).

In the context of the Convention, different types of indicators should be taken into account – on the one hand, indicators concerning the implementation of the Convention's plans and actions at national and regional levels. These are termed "implementation indicators." On the other hand, there are indicators governing the impact of action undertaken to combat desertification.

The United Nations Commission for Sustainable Development (CSD), in association with SCOPE and the UNDP/UNSO, OCDE and the FAO have established a working program to define sustainable development indicators (SCOPE, 1995; CSD, 1996). Indicators governing desertification or land degradation are included in this program. Several international workshops have been organized leading to the adoption of the "Pressure – State – Response" (PSR) scheme to provide a logical framework for the organisation of indicators. This relies on the notion of causality – human activity places pressure on the environment and changes its state as well as that of natural resources. Society responds to these changes by adopting corrective measures. One advantage of the PSR framework is to highlight the relations between human activity and the environment; however, it tends to suggest such relations are linear, whereas, in reality, they are much more complex.

Numerous organisations have developed studies and research programs about indicators (SSO, 1996, 2001). However, it is currently noticeable that, where a number of research studies have dealt with indicator application at different levels, few indicators have actually been tested or calculated and even fewer are effectively operational. Affected countries find it impossible to include the indicators they need in their reports. At the present time, this is a major omission. One of our priorities is to develop the use of existing indicators and to test them in comparative situations.

Observatories.

The development of methods governing both assessment and monitoring of the environment and the impact of countermeasures against land degradation relies on effective long-term monitoring networks which employ compatible data collection and transfer techniques. The idea of such observatories is to collect necessary data based on similar foundations and to follow how processes evolve over time while enabling the definition of reference situations. They enable the development and testing of indicators and tools that assist in decision-making and which incorporate these indicators. They also constitute privileged sites of research into the study of mechanisms and processes as well as on the factors determining evolutions.

The Sahara and Sahel Observatory has implemented a Long-Term Ecological Monitoring Observatories Network (Roselt) for the zone around the Sahara (Sso, 1995). This measure was taken in consultation with African countries and is destined for their use to assure long-term monitoring of desertification and to develop associated research techniques. It is made up of a network of observatories connected at the regional level of the Sso geographical zone on the African continent. The Roselt project was built according to a bottom-up approach, starting proposals from nations of suitable sites and research and monitoring teams. Appraisal and designation was then carried out, leading to the selection of 23 observatories under the Roselt umbrella. A restricted number of 12 pilot sites were selected for the first phase of the project. The project received the financial backing of several sponsors including the French Global Environment Facility, The French Cooperation and the Swiss Cooperation.

The Roselt strategy stands out as a an essential contribution to the understanding of environmental phenomena and their relevance to the problematic relations among global changes, sustainable development and measures to combat desertification. Roselt is a tool for both research and development in three ways:

It contributes to the improvement in the potential of our basic knowledge about the functioning and long-term evolution of ecological and agro-ecological systems and about the co-viability of ecological and socio-economic systems, assuring the scientific and statistical monitoring of the environment to enable characterization of causes and effects of degradation of areas, on the one hand, and to better understand the mechanisms that lead to these phenomena, on the other.

It assists in the application of knowledge, by classifying it, processing data and making it available, as well as by elaborating indicators and results at different local, national and regional levels. The results obtained about the state of the environment, its evolution and its relation with social and

economic movements will go on to be applied as tools for the establishment of sustainable development and environmental protection plans and strategies to support development programs and decision-making. They could possibly enable elaboration of plausible evolutionary scenarios.

It assures the learning, demonstration and study of environmental questions and their inclusion in developmental politics and programs as well as in the combat against desertification.

Tools to monitor from space.

Mapping and monitoring of degradation spread over the earth's surface constitute two key sources of knowledge about the phenomenon of desertification. They are indispensable to the instigation of combat plans and sustainable programs employing natural resources in arid zones and in particular in the Mediterranean.

There has been much study in the field about the processes of degradation and the dynamics of ecosystems and it is difficult to draw general conclusions from results obtained on a larger or even regional scales with any degree of certainty. Detailed information about the current state of plant life and soil on a regional scale is often not available. Precision field studies are irreplaceable but do not allow for detailed regional cartography due to their high cost, their lack of sufficient standardisation and because of difficulty accessing certain areas. Remote sensing from satellites is one source of alternative information. However, radiometric data collected does not correspond directly to the data that is required and has to be interpreted to obtain information (Bonn and Escadafal, 1996).

Thus, studies of South Tunisia and the desert fringe of the Nile (VSD, 1993-1996) within the framework of the "Desertification Watch with Satellites" project (the VSD project), financed by the European Union for its "Avicenne" program, set out to measure changes in the surface properties of arid environments studied by satellite and to integrate additional data into this information so as to obtain an effective instrument for monitoring. The research clearly demonstrated the feasibility of monitoring desertification by satellite. Results obtained showed in particular that some parameters (colour and composition of soil, its texture, and degree of vegetative cover), indicators of the state of desertification and its evolution, could be obtained from space by satellite. The colour and shine of surfaces recorded by satellite image represent, for example, a good indicator of the drift of shifting sands. On the whole, the VSD program has highlighted that satellite techniques, combined with a good knowledge of the terrain under study, enable the detection of both the progression of degradation over arid zones and its restoration through the positive effects of countermeasures and protection.

Beyond such advances, it appeared that the diversity of methods used to monitor arid environments made it difficult to compare conclusions drawn from one area to the next, or even from one team of researchers to the next. This recognition highlighted the need to lend a regional dimension to the fine-tuning of monitoring tools. Several programs have been developed, particularly with European Union assistance. In the Mediterranean zone, we will cite the following projects: Medalus (Mediterranean Desertification and Land Use, coordinated by King's College, University of London), Demon (Satellite-based Desertification Monitoring in the Mediterranean Basin, coordinated by the University of Trier in Germany, for the northern bank of the Mediterranean), and the Cameleo project (Changes in Arid Mediterranean Ecosystems on the Long-Term and Earth Observation, coordinated by the Joint Research Centre in Ispra, Italy, for North Africa). Their scientific method is based on results collected by their different partners. Their task consists of identifying indicators of local ecological changes on the ground (whether deteriorated, stable or restored), determining those factors that are detectable from space, seeking out the most suitable high resolution satellite data (while preparing for future data collection), fine-tuning processing algorithms and result presentation methods. Finally, the creation of models of observed changes means that plausible evolutionary scenarios may be put forward.

Desertification of the environment from local to global scales. Land degradation and climatic change.

There is a constant debate questioning how desertification interacts with climatic change. The terms are both complex and controversial. The difficulty here arises from the fact that our knowledge about the processes of land degradation and about mechanisms of climatic change are still very incomplete. The debate may be summed up by four essential questions about which we only possess fragmentary information.

1 Have recent regional climatic fluctuations increased desertification? Following a period of prolonged drought in Sahelian Africa, it was observed that the reduced rainfall and its greater variability increased the vulnerability of natural resources to degradation. But it was also observed that the impact of such drought was weak or negligible where human and animal impact was weak or non-existent. For all those researching this question, the intensification of drought phenomena is not at the origin of desertification but constitutes an important factor in the increase of anthropogenic effects on land degradation in dryland zones.

2 Are global climatic changes and subsequent global warming responsible for periods of increased drought? And with what consequences for desertification?

Since the end of the 19th century, the planet has been affected by large scale warming which has lead to an overall increase in air temperature of 0.5°C. This warming is however not the same in both hemispheres and it varies with latitude (Janicot, 1996). Scenarios based on global circulation models all anticipate a general increase in annual temperature, without being specific about seasonal variations. They are not in agreement however over possible rainfall changes in subtropical and tropical latitudes.

In the case of Western Sahelian Africa, climatologists increasingly believe that there is actually a link between global temperature changes and rainfall. Their conclusions are based on the effect that higher temperatures would have on the surface water of the South Atlantic and the consequent impact on Sahel rains. However, if surface water temperature increases are caused by global warming, we cannot dismiss the hypothesis that there are long-term cyclical changes to ocean temperature that have no relation to global warming and about which we know very little. At present, the intergovernmental think tank monitoring climatic evolution believes that continued global warming will lead to higher temperatures, lower humidity in the Sahel, increased variability of rainfall and storms of higher intensity.

To sum up, and despite existing uncertainties, it seems that foreseeable global climatic changes should take the form, in subtropical dryland zones, of an increase in arid conditions, which would increase populations' pressure on resources and land degradation.

3 Has land degradation, in return, had an effect on the local or regional climate?

On the local level, there have been hypotheses suggested concerning the mechanisms connecting local rainfall to variations in the nature of the surface of the soil. Such interaction is said to be related to an increase in albedo from the surface and thus to a reduction of both the energy available to the soil and the quantity of humidity present. The validity of this hypothesis seems to be contested, in particular due to divergences between the scales of modifications observed and those necessary to produce models of phenomena.

Among the experiments and measurements that have been made, results for the Sahel, for example, have shown that the land-atmosphere feedback effects do exist but remain weak compared to those effects produced by ocean surface temperature variations. It may be said that the desertification process is not the main cause of drought in the Sahel, but it might have contributed to enhancing the significance and persistence of the observed pluviometric deficit (Janicot, 1996).

Climatologists are highly cautious about the existence of strong feedback between land degradation and the evolution of the local climate. Any effect

of this type would be minor and mainly dominated by the possible effects of global climatic change in these regions.

4 Does the degradation of arid land have an effect on global climate? Newly emerging documentation and models of the impact of changes on the Earth's atmosphere caused by human activity in dryland zones in global energy terms have met with a certain degree of success despite the complexity of the processes at stake (Gef, 1995). General global atmospheric energy balance might be influenced by any one of the following: changes in albedo ratios; soil humidity and water presence changes; changes in surface texture; dust emission and variations in carbon emission or absorption.

Each factor's influence varies according to the zones concerned – arid, semi-arid etc. In very arid zones, the albedo modification would be the dominant factor relating to the evolution of soil surface constituents. Wind erosion produces considerable dust emission, which, once in the atmosphere, produces a change in radiative balance.

In less arid regions, where soil humidity is higher, zones affected by desertification more often demonstrate an increase in temperatures linked to the reduction of evapotranspiration. This phenomenon has also been noticed during prolonged drought.

On the issue of carbon emission or retention, energy consumption levels remain very low in the zones concerned and they contribute little in this respect to CO_2 emissions. A reduction to ecological systems and agricultural and grazing zones in the region would lead to an increase in emission and to a reduction in retention capacities. The periodic burning of grassy areas in semi-arid or sub-humid dryland zones contributes considerably to the emission of CO_2 and particles. However, where human pressure on the environment is moderate and the balance between cultivated and fallow land maintained, carbon emissions are compensated for by absorption in biomass production and the net contribution is weak. However, where human pressure is augmented, with excess land stripping, a reduction in plant cover and of the biomass, the net contribution increases with land degradation.

Generally, an increase in plant cover, particularly ligneous vegetation, has a significant effect particularly for carbon absorption and the prevention of land degradation. Recent studies seem to show that in dryland zones, soil plays a significant role in carbon absorption and that the control of degradation and soil loss may be important in combating global warming. However, this point is far from being recognised as fact by all experts and more precise research on the carbon cycle appears necessary.

It is probable that land degradation in dryland zones does contribute to climatic changes on a global scale. However, the relative importance of this contribution is not known. If it was recognised and verified that land

degradation in dryland zones has an influence on global climate, then combating desertification would take on increased importance for the international community and notably in developing countries.

Land degradation and biodiversity.
To this day, arid lands have not enjoyed the attention needed to address questions of the preservation, conservation and economic development of their biodiversity in national and international strategies. This is particularly the case in Africa around the Sahara.

Arid conditions have increased and developed in these zones over a period of time and been allied to long-term anthropogenic pressures. This has lead to processes of adaptation and evolution that result from the existence of original genetic lineages and the presence of a whole range of focal points assisting adaptation and evolution. Many arid zone species have ecophysiological and genetic properties that help them adapt to drought conditions, assisted by the diversity of their habitat ecosystems. This makes these zones precious resource centres for the future. Studying the role of biodiversity in the way ecosystems function has shown (Di Castri and Younés, 1990) that higher ecosystem biological diversity leads to better uses of non-biotic resources and to greater stability when faced with habitual or catastrophic variations to the environment. Biodiversity plays an important role in the resilience of ecosystems by reinforcing their capacity for recuperation after disturbance.

The fact that agricultural practices date back a long way in these zones has meant that local populations have appropriated significant supplies of traditional varieties of cultivated plants and breeds or populations of domesticated animals that are well adapted to their surroundings. Some varieties are known to possess genetic characteristics that could be useful throughout the world in improvement programs.

For example, recent studies have shown how important traditional varieties of millet and related wild species in the Sahelian zone are as genetic resources. Likewise, there are several field species cultivated around the world, such as *Cenchrus ciliaris*, which also originated from these zones. Furthermore, these areas constitute a sources of genetic diversity for future species improvement, and the importance of biological diversity within them should be extended to other biological groups, such as micro-organisms. A recent programme has been studying the diversity of rhizobia with a view to using them to restore degraded lands in the north and south Sahara.

Biodiversity is mainly lost through desertification and through changes to modes of land use and its cover in dryland zones, due to over-exploitation of populations and the destruction of habitats. The inter-relatedness of land

degradation prevention, sustainable rural development and biodiversity conservation should engender a form of co-ordination and synergy among specific sponsor-led and State-level programmes.

When land supporting biological diversity degrades, it affects the flora of the area and certain species that make up the pharmacopoeia and traditional farming systems become rarer, and even disappear. It also affects wild and even domesticated fauna so that effective management and conservation of breeds can no longer be guaranteed. Previously permanent water sources become intermittent, upsetting the biotopes of numerous species. Migratory birds, part of the world's heritage, find their habitats increasingly precarious in the remaining humid zones of dry areas.

For a long time, the protection of biodiversity has been maintained by creating national parks and designating protected areas. The developers of such parks have generally considered human activity as predatory. Faced with an increase in pressure on resources, these "sanctuaries" have become of major significance to farmers, hunters, and pastoralists – in land ownership and forestry terms, with their availability of species that have disappeared from cultivated zones. The majority of players involved (States, NGOs development and nature conservation groups, and farming organisations) today recognise the necessity to associate biological diversity conservation strategies with the economic development of its potential in different communities. Likewise, beyond the general need to conserve protected areas, international authorities recognize how important biodiversity protection is in exploited areas and ecosystem preservation programs.

Given the role that biological diversity plays in ecosystem resilience and the fact that ecosystems will have to adapt to probable, if not foreseeable, climatic modifications, preservation of local biodiversity and the encouragement of floristic adaptation to drier or more humid conditions is doubtless one of the major goals at stake to promote future evolutions. From this point of view, maintaining ligneous reserves that are sufficiently dense and ecosystems that are sufficiently diverse to encourage the conservation of high levels of biodiversity in situ, represents another major goal.

In the area of genetic resources for farming, there is a combination of factors at stake – availabilities of local varieties that are well adapted to agro-climatic conditions and of species that may represent new opportunities for economic development in local as well as international markets. The conservation of species and genes in situ is a crucial factor in particularly because ex situ gene banks are very costly and are difficult to maintain for long periods. Such conservation also implies, however, acknowledging the important role that farmers and communities fulfil as major players in species preservation.

Biodiversity must be considered not only as part of humanity's global heritage but also as a potential basis for local development that links in well with current practices in a way populations can understand. This means that the study, economic development and conservation of biodiversity are not limited to a handful of particularly rich zones but spread around regions. By studying and monitoring biodiversity, we should be able to extract the correct samples from their original biological dry-land lineage. This work will enable us to draw up lists and maps of taxons present and to establish a critical evaluation of their vulnerability in this respect. The study of populations' activities as they relate to biological diversity should enable us to draw up principles for economic development and for its use within viable long-term development frameworks.

Land degradation and water resources.
In dryland zones, water resources are closely dependent on climatic conditions, but also on plant cover, land use and soil condition. These different elements will be modified by the process of desertification. Although the effect of desertification on local climate still remains a matter for debate, most authors (Thornes and Burke, 1999) do consider that there is an effect that results in an increase in the persistence of drought phenomena.

Changes in plant cover, soil surface degradation, and changes to the physical properties of soils, due to the disappearance of organic matter, will lead, on a local scale, to changes in the components of the water cycle and the hydric balance: lower infiltration, an increase in immediate runoff, and a reduction in evapotranspiration. The latter will lead to a change in surface energy balance and to an increase in temperature. Higher rates of immediate runoff will lead to soil erosion, thus, to the reduction of its capacity to absorb water to support vegetation. All of which leads to an increase in aridity in both the climatic sense (through increases in temperature and persistence of drought incidents) and the edaphic sense, leading to the degradation of water supplies in the soil (Floret and Pontanier, 1982; Grouzis et al., 1992).

As concerns water reservoirs in areas of relief, the same phenomena (plant cover and infiltration reduction, immediate runoff, and soil erosion) will have repercussions on hydrological systems and drainage. The reduction of infiltration and of deep drainage will lead to a lowering of the phreatic table resulting in the reduction of river drainage in terms of flow as well as duration. The distribution of water reserves to supply populations will be drastically reduced over time. Meanwhile, runoff and rapid drainage will lead to water loss beyond the zone in question and to flooding, creating major,

and even dramatic, consequences for infrastructures and further flood problems downstream.

The erosion of soil from water reservoirs in areas of relief, and rapid drainage associated with it will also shift considerable quantities of sediment. Some authors (Thornes and Burke, 1999) cite figures of 20 to 200 tons per hectare and per year in the Mediterranean zone. The transportation of such sediment will have important consequences on the stability of riverbeds downstream, on sedimentation and on damming, but also on the silting up of estuaries and deposits at sea.

Not only does water constitute the essential base of agricultural production and economic development in dryland zones, but it is also one of its major environmental constituents, which has a significant impact on the health and living conditions of populations. The direct and indirect effects of desertification are to increase the rarity of available hydric resources in affected areas. This brings with it harmful consequences for adjacent zones, including international waters.

Desertification and development.

Natural resources: public interest and basis for development.

Environmental preoccupations are taking an increasingly important place in public opinion and in social demands, particularly in northern countries. The "productivist" discourse of the sixties has disappeared, sometimes replaced by a "conservationist" one opposing development and environment. Southern countries have problems accepting the rhetoric of the privileged and the efforts that are demanded of them. The World Bank and international organisations underline the synergy and not the competition between the environment and development ("Economic development and rational management of the economy are complementary aspects of the same programme – without good environmental protection, there can be no viable development; without development, there can be no worthwhile environmental protection," The World Bank, 1992). A southern point of view on the environment, however, is considered as the key to sustainable development and its integration into development plans. Its emergence is often held back due to the urgent measures required to respond to immediate problems. Analysis shows that in the south, development and environment are closely interdependent. The reasons for this are threefold:

1 Firstly, natural resources constitute the basis of productivity of ecological systems and habitats. In developing countries, exploitation of renewable natural resources contributes, in a determining way, to the satisfaction of the essential needs of a large part of the population. For food, health and daily life, humankind exploits a wide variety of living

natural resources. National economies are largely based on these resources, which contribute moreover, directly or indirectly, to the majority of a country's exports. Thus according to the World Bank, in the majority of African countries, the share of agriculture and the exploitation of renewable natural resources in the gross domestic product in 1992 was higher than 30%. The abundance and renewal of natural resources are controlled by fluctuations in the environment. Their future depends on the use to which societies put them and how exploitation techniques are controlled, as well as the way they are distributed and appropriated.

2 Human activities linked to development have important repercussions on the environment and ecosystems. During the period 1960-1990, it has been estimated globally that a third of the rise in farming production was due to increases in farming areas. The increase was down to farming marginal, fragile, barely productive lands to the detriment of natural ecosystems. Such farming, in the absence of adapted management methods, encouraged the degradation of land. It is estimated that globally 1,960 million hectares of land, or 17% of the farmable surface of the earth, have deteriorated due to human agency since 1945 (Gcrai, 1994). The continued and rapid increase of the population and of urbanisation leads to increasing and diversified demands in food requiring a considerable increase of production and in the efficiency of distribution networks. In 1950 in Africa, alongside his own consumption, a farmer had to feed 0.18 non-farming inhabitants. The ratio rose to 0.45 in 1980 and will reach 1.21 in 2010 (Cce, 1984). The quantity of food products the farmer puts on the market will have multiplied by 7. Often, satisfaction of short-term urgent needs, associated with unforeseen climatic, demographic and economic crises, leads to harmful practices, setting in motion desertification processes. Access and management control mechanisms for natural resources implemented by traditional societies then become obsolete under the pressure of demand. In various places there has been a saturation of available agricultural space, resulting in particular in a reduction in the time land is left fallow and a break with balanced rhythms (Floret et al., 1992). In the future, production increases should therefore be carried out essentially on already farmed land and not by increasing surface areas.

Tropical and Mediterranean zones are typically rural societies under social and demographic transformation, with fragile ecological systems of little resilience. They survive with high drought constraints and have coped with strong anthropogenic disturbances (such as desertification, aridification, deforestation, etc) for decades. The potential of these areas is reduced more quickly and the speed of recovery is slower than in climatic zones that are less restricted. Generally, what we see is an increase in aridity of edaphic origin,

a reduction in water efficiency throughout an ecological system as well as profound changes to plant cover and landscapes that affect the system's productivity and its populations' living conditions. The irrigation of land, particularly in arid and semi-arid zones frequently leads to salinisation problems which tend to sterilize land and lead to the abandon of its irrigated perimeters. The size of the areas concerned (50 % salinised land in Iraq, 30 to 40 % in Egypt, 35 % in Pakistan; Barrow, 1994) attests to the seriousness of the problem, which is made even more acute because planning is costly and irrigable land has limits to how far it can extend.

3 Finally, pressure on resources and environment depends on the functioning of social systems. Rural development cannot be reduced to processes of technical or economic evolution; it is a dynamic and based on social construction shaped by multiple actors and determining factors. This social dynamic conditions what values areas take on through use of their ecosystem's natural resources, agricultural production systems and other diverse rural activities. Rural areas and natural resources are crucial to different groups within a population, or for different populations, for their material and social reproduction as well as that of their existence. The way in which human societies manage space and resources is strongly marked by cultural constraints which underlie their perception of the environment, and their capacities to evolve and appropriate new technologies. For a society to protect its environment it has to be economically possible and its environment has to be part of its reference system. Although there is no one-to-one relationship, poverty, and the short-term survival strategies it imposes, constitutes one of the most important causes for "mining" style exploitation of resources and the degradation of environments.
The destruction of natural resources and loss of land productivity constitutes a major obstacle to development in these countries which may lead to major catastrophes that are difficult to reverse – such as famine, land abandon, large scale migration (refugees from the environment). It is estimated that there are currently 25 million refugees, that is to say, 58% of the world's total refugees, who are migrant due to environmental catastrophe (International Federation of Red Cross and Red Crescent Societies, World Disaster Report, 1999).

Desertification and poverty.

The reduction of poverty is one of the major directions of intervention in developing countries. Debates and decisions around the subject of poverty reduction, in the field of public aid to development and that of multilateral institutions, reflect the evolution of certain currents of economic thought (the works of Amartya Sen, in particular). Economic growth can only play a role in reducing poverty if it is integrated into an environment enabling

the poor to benefit from economic opportunities that are generated. The analysis of the concept of poverty leads to a frame of reference which distinguishes monetary poverty – relating to income, from poverty in living conditions and poverty of capacities. The idea of monetary poverty is interlinked with of standard of living and results from a lack of resources leading to insufficient consumption. Poverty in living conditions implies the impossibility of accessing collective services enabling satisfaction of fundamental needs such as health, education, etc. Poverty of capacities refers to a lack of means to bring out the best of ones individual capacities, to seize the opportunities that present themselves, and have one's opinions heard.

Numerous authors underline the strong link between desertification and poverty. According to Ph. Dobie (2001), the proportion of poor people among populations is noticeably higher in dryland zones, especially among rural populations. This situation increases yet further as a function of land degradation because of the reduction in productivity, the precariousness of living conditions and difficulty of access to resources and opportunities. Decision-makers are highly reticent about investing in arid zones with low potential. This absence of investment contributes to the marginalisation of these zones. When unfavourable agro-climatic conditions are combined with an absence of infrastructure and access to markets, as well as poorly-adapted production techniques and an underfed and undereducated population, most such zones are excluded from development.

As a result of a lack of capital and of economic opportunities, poor populations are lead to exploit their limited resources in a way that satisfies their immediate needs, even if this short-term exploitation compromises the long-term survival of these resources and reinforces their vulnerability over time (Smith and Koala, 1999). Where poverty engenders land degradation, desertification is in turn a major contributing factor to poverty.

Action to combat poverty takes place in three major directions – creating economic opportunities, supporting and strengthening aptitudes and institutions that work closest to populations (the concept of "empowerment"), and assisting populations themselves, particularly the poorest sections, to reduce their vulnerability. This action also coincides with measures to combat desertification, which aim to diversify activities and revenues to reduce the pressure on resources, develop capacities, decentralise resource management, secure access to resources, reduce populations' vulnerability faced with unforeseen climatic events, etc. Ph. Dobie (2001) underlines the necessity for public investment in arid zones to combat desertification and to promote sustainable development. Examples, in particular that of the district of Machacos in Kenya, seem to show that there may exist significant returns

on investment in these zones. At State level, it is a good idea to show how national action programs to combat desertification (NAP) should be associated with intervention in other directions – in particular strategies to reduce poverty (PSRP). This requires, among other things, that action to combat desertification is not only directed towards aspects of resource protection and conservation, but also that they aim to develop productivity in these zones and diversify opportunities in a modern economic framework.

Combating desertification and promoting sustainable development. Desertification and land degradation in dryland zones results essentially from human activity. It is rare that man degrades the resources and the land he exploits intentionally. At every latitude, humankind has managed to create systems adapted to the most difficult of conditions. However, it should be emphasised that development in arid zones is seldom continuous (Mainguet, 1995). More than in other ecosystems, it is characterised by progress and regression. The fight against desertification and land degradation is part of a global approach to environmental and development problems. The viability of action undertaken to combat land degradation is often determined by the increase and diversification of resources enabling an increase in the standard of living of populations. An effective strategy that aims to reduce or halt land degradation should take into account sustainable development criteria.

Development of viable long-term farming strategies in tropical countries need to meet four major challenges. The first is that of satisfying the food needs of populations with high rates of increase and that are becoming increasingly urbanised. The second involves the preservation of natural resources and the environment. The third concerns world economic competition which forces agricultural producers in developing countries to take on producers from other regions of the world even in their own market places. The final challenge consists of redistributing wealth more equitably, without excluding important sections of societies from development (Cornet and Hainnaux, 1995). Ecological or environmental viability cannot be understood from a purely conservationist point of view. It is a question of preserving the environment and resources so as to preserve the productive capacity of environments in a natural or human way. Sachs (1992) highlights the necessity of extending the productivity of natural systems by intensifying and diversifying the way different ecosystems' potential resources are used, while establishing methods of management and technology that reduce any negative impact on their functioning to a minimum.

Sustainable development, in the context of desertification, means above all halting the processes of degradation and stabilising the equilibrium between

resources and exploitation, while re-establishing viable social and political frameworks for natural resource management. Because of demographic growth, methods of land use that are traditionally extensive have major negative impacts on plant cover and soil. More intense farming and breeding, plus taking the fragility of the area into account are thus indispensable to limit stripping away of vegetation cover, overgrazing and deforestation – all of which propagate desertification.

This intensification does not contradict the objectives of ecosystem conservation and world environmental preservation. In fact, it should enable the limitation of anthropogenic pressure over reduced areas, thus encouraging the conservation of biotopes.

The convention on desertification, called for by the poorest countries – in particular those on the African continent – is doubtless the environmental agreement that most closely links the environment and development (L. Tubiana, 1999).

Combating desertification.

Appropriate techniques for economic and institutional changes.

Techniques of combating desertification have been the subject of much research. There is unfortunately no ready-made scientific solution to control desertification and nobody is in a position to provide a simple response. There are however a number of partial solutions that have been tried and tested for particular conditions in particular regions. Solutions are specific to each place and each situation. Literature on the subject today is abundant and various technical solutions exist for most problems encountered. The quantity of resources to be marshalled to implement technical solutions varies as a function of the state of degradation of the area.

Solutions to combat desertification are based on controlling causes of land degradation. As desertification is above all the result of human agency, it has become apparent that attention should be paid to the three main areas of activity in which it appears: grazing zones, farming in pluvial areas, and irrigated zones. This distinction mirrors the way countermeasures operate, in that the causes and types of desertification – and consequently the methods for combating it – are largely specific to these three fields. Generally, techniques and methods to combat desertification may be divided into four categories corresponding to a variety of complementary strategies: Corrective methods aiming to halt a phenomenon and to reverse existing degradation. We may cite here dune fixation, combating shifting sands, anti-erosion, and water and soil conservation techniques, reforestation, as well as techniques of ecosystem rehabilitation (Pontanier et al., 1995). Techniques enabling the better exploitation of resources, so as to increase

productivity and improve regeneration. These correspond to formulating improved and adapted practices for agriculture, breeding, the use of the biomass and soil.

The finalizing of integrated management resource models. This relates to the resolution of conflicts, the creation of negotiation and decision-making locations and the establishment of rules governing management and access to resources.

The implementation of institutional and political mechanisms suitable for economic development and the preservation of natural resources. Among them the establishment of legislation and regulations, the implementation of economic and financial incentives, the development of infrastructures, and the reinforcement of human resources.

Countermeasure techniques and methods should be adapted to the particular conditions of the zones concerned. In a study for the French Development Agency on the subject, Jouve et al. (2001) put forward three major demands:

1 That techniques should be contextualised, that is to say that the conditions in which countermeasure techniques are implemented should be taken into account so as to select the most relevant. Three main types of condition should be taken into consideration when justifying choices: the agro-ecological context, defining the biophysical characteristics of environments, production systems and agrarian dynamics.

2 The involvement of the various actors engaged in the struggle against desertification, which is one of the essential conditions of the sustainability and success of action undertaken.

3 The existence of an adapted institutional framework.

What projects respond to populations' needs?

Numerous projects to combat desertification have been undertaken in the last twenty years, representing a considerable investments both financially and in terms of the mobilisation of human resources. However, the results of these efforts have generally been unsatisfactory and many projects have not reached their goal. It is generally admitted (Warren and Agnew, 1988; Rochette, 1989; Chambers, 1990) that the causes of low efficiency or project failure have been:

1 The fact that the problem of desertification has not been considered in the global context of the socio-economic development of countries involved and that the countermeasures taken have not been integrated into rural development programs.

2 An often-erroneous approach to problem-solving based on a mis-recognition of processes and inadequate diagnoses.

3 The fact that action was taken with little reference to populations' needs, their priorities or their savoir-faire.

4 Weak overall effectiveness of aid programs, linked to poor co-ordination between agencies and insufficient decentralisation at national level.

Via the new perspectives set in place and by breadth of experience, we may attempt to define a certain number of desirable general criteria for projects to combat land degradation in dry-land areas: The approach should be integrated, combining the prevention and combat of land degradation with development programs and environmental strategies defined at national level; this approach should be directed towards local populations and communities as a priority.

The essential aim of projects is to bring solutions to populations' problems, within a framework of real involvement, enabling them to increase their resources and to manage them over the long term (assuring rights and income for poor populations).

Projects should be based on solid scientific knowledge of processes and causes, and on precise local diagnoses. They should bring significant contributions to resolving problems of land degradation in dryland zones or rehabilitation of already degraded zones while ensuring adoption of durable resource management systems. In this domain, projects should be innovative and results should be reproducible.

Projects should adopt a flexible learning approach, allowing for changes of direction if necessary. Projects should be long-term and include several phases.

Effective coordination should be established between intervening parties based on quality, commitment and continuity of the workforce.

Monitoring and evaluation mechanisms should be implemented, based on agreed repayment schedules and quantifiable objectives and measurement parameters, while encouraging the development of the countries' institutional capacities.

The United Nations Convention.

The United Nations Convention to combat desertification aims to guarantee a long-term commitment to the parties concerned through a legally-binding document. Its aim is to combat desertification and to alleviate the effects of drought on seriously affected countries, those in Africa in particular, through measures that take effect at every level. This process should be supported by cooperation and partnership arrangements internationally, within the framework of an integrated approach that is compatible with that of the Action 21 program. The underlying aim should to institute sustainable

development in the affected zones. The convention includes a main text with forty articles and four appendices relative to it regional level implementation: Africa (Appendix I), Latin America and the Caribbean (Appendix II), Asia (Appendix III) and the northern Mediterranean (Appendix IV). A fifth Appendix concerning the membership of the convention of central and eastern European countries is on the way to being created. France is unaffected and is not involved in Appendix IV. However, it has an observational role and assists in some collective actions.

For its implementation, the Convention set up a number of bodies. The Secretariat, the permanent executive office, is based in Bonn. It takes care of promotion of the convention, the organisation of meetings, the sending of reports and the co-ordination of other publications. It is also in charge of liaison with other organisations or conventions. The Conference of Participating Countries (CDP) is at the head of the convention, and is the governing and decision-making body. It is organised by the Secretariat and brings together all signatory countries. International organisations and non-signatory countries are also present as observers. Decisions are taken by consensus. Instead of creating a new fund to combat desertification, the convention has underlined the necessity to improve management and to mobilise and co-ordinate existing funds, by creating a Global Mechanism. The Conference of Participating Countries has made it responsible for identifying existing financial resources. It will mobilise and channel financial resources from bilateral and multilateral organisations on all levels allowing it to draw up and execute projects and programs. Another subsidiary body of the convention is the Committee on Science and Technology (CST), made up of representatives of the States. It meets at the same time as the Conference of Participating Countries and deals with scientific aspects, concerning co-operation and the transfer of technologies.

Interdependent and innovative approaches.

The United Nations Convention to combat desertification recognises the global scale of the problem. It also underlines that efforts to counteract desertification should be accompanied by measures aiming to encourage economic and social change and be conceived to remedy the causes of desertification. In other words, efforts should be an integral part of the development process (World Bank, 1998). The convention's approach is based on obligations and on the principle of solidarity between countries affected and developed countries. It obliges countries concerned to accord priority to the combat against desertification and against effects of drought, to attack the underlying causes of desertification, in particular the socio-economic factors, and to collaborate in this direction with the populations

concerned. At the same time, developed countries make a commitment to actively supporting these efforts and to supplying significant aid to this end.

A number of guiding principles result from the convention, which should underpin the application strategies implemented:

The fight against desertification and land degradation is part of a more global approach to environmental and development problems. An effective strategy aiming to reduce or halt land degradation should take into account the criteria for sustainable development: environmental integrity, economic efficiency and social equity.

A participatory approach is essential in the definition of strategies, action plans and countermeasures. The participation of affected communities seems to be a precondition to the success of any preventative action or countermeasure. Participatory approaches have greater chances of sustained success, as much in terms of project planning at a local level, as in policy ideas at the national level.

By laying emphasis on the participation of local actors in development and decentralisation of the decision-making process, the convention advocates a new role for the State. The new perspectives laid down by the convention are leading to evolutions in the role of the State. This new role is to be found in particular in the co-ordination of international initiatives and the setting up of adequate legislative and regulative frameworks, enabling the development of national consultation mechanisms and capacity building in local communities for self-management of their natural resources in the framework of a development program that is more sustainable.

Science and technology constitute essential tools in the struggle against desertification. The causes and effects of desertification are far from clear and it is advisable to strengthen international co-operation as concerns research and scientific monitoring. Science and technology must be deeply involved if we hope to respond to populations' real needs.

A strategy to prevent and fight against desertification should be based on the implementation of concrete projects, capable of bringing suitable solutions to major problems encountered locally.

The implementation of the convention fundamentally depends on National Action Plans (NAP), the establishment and drawing up of which is the responsibility of the countries involved. The convention asks affected countries to establish national action programs to produce an inventory of their situation and suggest a strategy of countermeasures. These NAP should be elaborated according to a participatory process involving the State, local groups, basic communities and farmers, from conception through to execution of the program.

Congenital abnormalities and difficulties

The Convention to combat desertification managed to undertake a change of direction but it has been less effective in setting up specific tools. Without major economic impetus and dealing with environmental subjects that only interest the poorer countries of the planet, it has had difficulty mobilising the international community (Tubiana, 1999).

Difficulties encountered concern budgetary matters. The Convention to combat desertification does not have a special fund for operations. Action plans may be financed via the World Environment Fund, but only in relation to actions concerning other conventions, such as biodiversity, climatic change etc. Current negotiations, should, eventually, enable direct financing from this fund. One promising finance ally is via specific operations for financing development projects. The Global Mechanism should play a facilitating role for project finance, but has had much difficulty in finding a place in bilateral and multilateral funding and in specifying fields of activity.

The Secretariat's operating budget and that of the convention's various bodies also constitutes a bone of contention between northern and southern countries. The Secretariat itself is considered as excessive by some countries. The complex mechanism of United Nations organisations leads to a proliferation of meetings and other workshops with results that do not match up to human and material commitments. A great many people make their living from such procedures, above and beyond concern for the populations affected. Unlike other post-Rio conventions, the Convention to combat desertification is not based on a strong stand from the scientific community. Neither does it have the backing of the scientific community. The CST, a subsidiary body of the Convention, brings together representatives of countries and – as a result of the number of members and the way it is organised – it is rather inefficient, contributing little to implementation of the Convention.

A certain number of crucial questions concerning the Convention's functioning, (in particular implementation procedures, the operational strategy of the Global Mechanism, and improvement of the CST's work), constantly lead to tense debate where little is achieved but a widening of the gap between developed and developing countries. A climate of mistrust is not conducive to the creation of long lasting partnerships, and the convention could be in danger of losing its legitimacy if these questions are not resolved to the satisfaction of all parties involved.

Real advances.

The Convention to combat desertification is doubtless the one environmental convention that deals with both environment and development in closest

proximity. It advocates the necessity of a synergy between economic policy, development plans and national programmes for environmental preservation in clear terms. It has been able to put forward a change in approach and has a fundamental objective to encourage governments to make commitments in terms of state policy or as aid development programmes, and to define legislative and regulatory programs enabling populations to organise themselves to manage their own natural resources.

The preparation of national action programmes has constituted a major exercise of resource mobilisation and awareness in the affected countries. Their establishment is on the way to completion, particularly in Africa. Even if results remain disappointing in terms of diagnostics of the situation and of definitions of combat strategies, production of the programmes has led to real participatory processes, which have encouraged different sections of the population to speak out, expressing their views and their needs. They have been important exercises in the management and mobilisation of resources, ranging from the empowerment of local actors to promoting awareness in public opinion via a revision of legislative and institutional frameworks. In many cases, their production mobilised enormous resources and significantly raised expectations. The NAP processes have up till now had an unexpected reach and impact, particularly as concerns the democratisation of relations between actors of civil society and their public powers.

Now projects and programs have to be implemented and the combat against desertification has to be integrated into the management of natural resources and the environment. One question, that of financing the combat against desertification is one that is becoming increasingly pressing. But there are others: Will developing countries be in a position to respond to the calls of developing countries? Will the Global Mechanism manage to mobilise a sufficiently large offer to respond to demand? And will the convention whither and become an organisation that is outdated and inefficient, or will it really become the partnership tool that it should indeed be?

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