

SD n° 1

OBSERVATORY
NETWORK
FOR LONG TERM
ECOLOGICAL
MONITORING

ROSELT / OSS



Conceptual, organizational
and operational framework
of ROSELT / OSS

RÉSEAU
D'OBSERVATOIRES
DE SURVEILLANCE
ÉCOLOGIQUE À
LONG TERME

OBSERVATOIRE
DU SAHARA
ET DU SAHEL



ROSELT / Oss Collection – Scientific Document n°1



Sahara and Sahel Observatory (Oss) has set up a Long Term Ecological Monitoring Observatories Network (ROSELT/Oss) in the circum-Saharan zone. In the framework of its programme of Environmental Monitoring, helping the policies of implementation of the National and Sub-Regional Action Programme (NAP and SRAP) to combat desertification. This device has been elaborated within and to serve the African countries, to ensure the long term monitoring of desertification and to develop associated research activities. An expertise mechanism has been undertaken, conducting to the selection, and then to labellisation by Oss, of twenty-five observatories in eleven countries. fourteen pilot-observatories have been activated in the first place of the programme, within the financial support of France and Switzerland.

This document is part of the « *ROSELT/Oss scientific and technical collection* », which includes the Scientific Documents (SD) and the Technical Contributions (TC).

SD are synthesis documents about the scientific bases of the programme or the scientific items related to desertification. TC are technical documents such as individual works (dissertations, PhD thesis, master dissertations...) or collectives works (thematic or geographic approaches) undertaken in the frame of the programme. Each draft leaflet of the ROSELT/Oss methodological guidebook is edited such as a TC. Once tested and validated by the whole body of the network, they will be grouped and edited such as Scientific Documents.

The aim of the « *ROSELT/Oss scientific and technical collection* » is to share, step by step, within the international political and scientific community, the scientific and technical advancements of the network in order to :

- a better knowledge on the causes, consequences, mechanisms and extend of desertification ;
- the elaboration of a monitoring system adapted to the conditions of arid zones for a better help to decision.

It highlights the permanent effort realised by the ROSELT/Oss network and completes the others products of the network : local databases, management tools of metadata, Local Environment Information Systems for the integrated processing of the information and the prospective simulation, web site (www.roselt-oss.org).

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**Conceptual, organizational and
operational framework of ROSELT/Oss**

ROSELT / OSS

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Warning : Annexes 2 (« *Data surveys in each observatory* ») and 4 (« *Certification procedure of potential candidates –PCT territories* ») on the original document (1995) have been removed from the 2004's edition, but are still available (in french) on the website www.roselt-oss.org

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Preamble

General context

As soon as it was launched, the International association Observatory of Sahara and Sahel (AIOSS – see “*list of abbreviations and acronyms*” at the end of this document) included the creation of a monitoring network for environment among its programmes and goals priorities. Is it worth reminding the many initiatives taken, over the last twenty years, to develop long-term ecological studies and environmental information systems ?

Oss had accordingly to consider the past efforts, and the specific features of the Oss zone, together with developers needs in the countries. This zone includes twenty-one countries around the Sahara, distributed into three sub-regions : North Africa (UMA countries and Egypt), West Africa (member states of CILSS) and East Africa (member states of IGAD).

The specific aspects of this zone are related to both ecoclimatology and socio-economy from an ecoclimatic viewpoint, the zone includes the Sahara, world largest desert which was particularly hit by droughts and desertification over recent decades. In terms of socio-economy, the zone is characterized by its fast increasing population, by severe stress in living conditions and in the social organization, contributing to exacerbate of drought and desertification.

In this context, Oss started a series of studies and consultations to design in establish a network aimed at :

1. a better appraisal and monitoring of desertification and land-degradation in peri-Saharan countries,
2. collecting necessary data to improve the analysis of causes and consequences of various environmental degradation processes,

3. identifying solutions to oppose the phenomena and, consequently, to provide managers with relevant information for decision making and rational management of natural resources.

The studies and consultations led to **creating a Long-term Ecological Monitoring Observatories Network (ROSELT)**.

The procedure was coincidental with the preparation of the United Nations Conference on environment and development, which was held at Rio in June 1992, and with the negotiations to produce the international convention on desertification adopted in June 1994. The network envisaged by ROSELT/Oss, and its actions, obviously reflect the conclusions and recommendations of this Rio conference, and are coherent with the application of International convention on desertification.

Major steps in ROSELT/Oss establishment

A pilot group was created as soon as 1991 to examine the studies and consultations in order to promote the network and to pin-point areas for inclusion in it :

- a concentration between specialists of Algeria, Egypt, Morocco, Libya and Tunisia was organized at Tunis in October 1991, on the occasion of the third meeting and biosphere reserves in the Mediterranean basin. It was followed by consultants missions to Algeria, Morocco, Tunisia and Egypt to identify priority sites ;
- for West Africa south of the Sahara (CILSS countries), Oss mandated Institut of Sahel (INSAH) in Bamako ; the inventory phase was concluded by a sub-regional workshop (January 1993). A specialists meeting was held at Dakar in May 1992 ;
- in East Africa south of the Sahara (Ethiopia, Jibuti, Kenya, Sudan and Uganda), the inventory was done by the East-African Wildlife Society (EAWLS), Nairobi. A sub-regional workshop followed (March 1993) ;
- an inventory of sites used of desertification monitoring was made by Unso, mandated by ROSELT/Oss, considering African, European and North American agencies (see UNSO-Oss report, 1991) ;
- major French research organizations (CNRS, CIRAD, ORSTOM, universities,...) and several international organizations (UNESCO, IUCN,...) involved in the Oss zone, were approached by Oss consultants ;
- a meeting at international level was jointly organized in Fontainebleau, France (July 1992) by Oss, ICSU (International geosphere-biosphere programme) and UNESCO-MAB to lay foundations for the Global Terrestrial Observation System (GTOS). ROSELT/Oss may be the African component of this system, focused on desertification monitoring and on development facilitation.

In July 1993, Oss appointed IARE as its executive agency, and requested them to carry on with documentation, and to establish ROSELT/OSS in close cooperation with Oss secretariat and with the concerned countries. Since then, and up to the production of this document, following steps are taken :

- preparation and finalization of a ROSELT/OSS initial workshop at Rabat (April 1994) ; participants in this workshop included representatives of all three sub-regions, *i.e.* Northern, Western and Eastern African UNESCO and FAO delegates, and delegates from France, Germany and Italy. The decision to officially start ROSELT/OSS was made by the participants during the meeting. The workshop proceedings (distributed in June 1994), are the most complete reference for methods suggested by ROSELT/OSS, for its conclusion within and international context and for actual proposals of all countries to participate in the network ;
- the period from July 1994 to April 1995 was mainly used to describe and label various Potential Candidate Territories (PCTs). This phase was based on thorough expertises carried-out by European and African specialists; this work ended in May 1995 and was concluded by an experts' conference chaired by the Oss director ; the meeting resulted in proposals for labelled PCTs to be considered by Oss secretariat.

Since August 1995, the ROSELT/OSS network is established from some thirty observatories as a first phase. From now on, its major tasks are : presenting the network to international partners, refining on methods to harmonize and collect data, negotiating with donors, and establishment ROSELT/OSS in the countries at the sub-regional and regional levels.

General definition of ROSELT/OSS

The Long-term Ecological Monitoring Observatories Network – ROSELT – is being established by the Sahara and Sahel Observatory – Oss. ROSELT is a group of observatories coordinated into networks at the regional level of the African Oss geographical zone. This zone includes three sub-regions for Northern, Western and Eastern Africa, totaling twenty on countries : Algeria, Burkina Faso, Cape Verde, Chad, Egypt, Erythrea, Ethiopia, Gambia, Bissau Guinea, Jibuti, Kenya, Libya, Mali, Mauritania, Morocco, Niger, Senegal, Somalia, Sudan, Tunisia, Uganda (**Figure 1a**).

ROSELT is specific of Oss ; this is the first African network to organize a scientific and statistical monitoring of environment, able to promote a description of causes and effects of land degradation on one hand, and a better understanding of mechanisms which produce it on the other hand. ROSELT/OSS is a regional set-up which provides reliable data on land degradation in the arid zone, appropriate biophysical and socio-economic key-parameters for desertification, and a description of environment in the Oss zone.

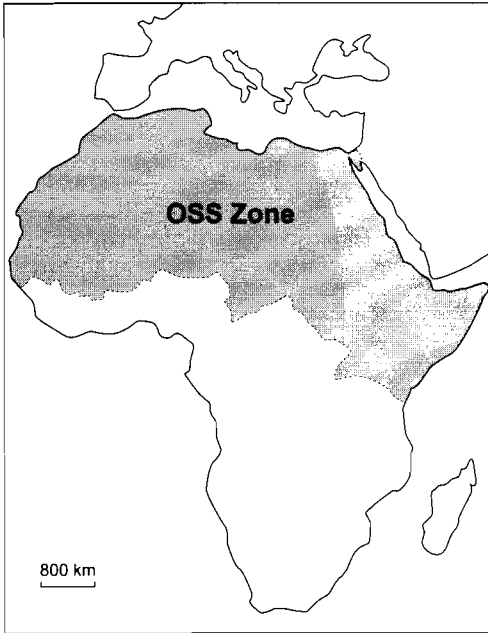


Figure 1a :
The Oss zone.

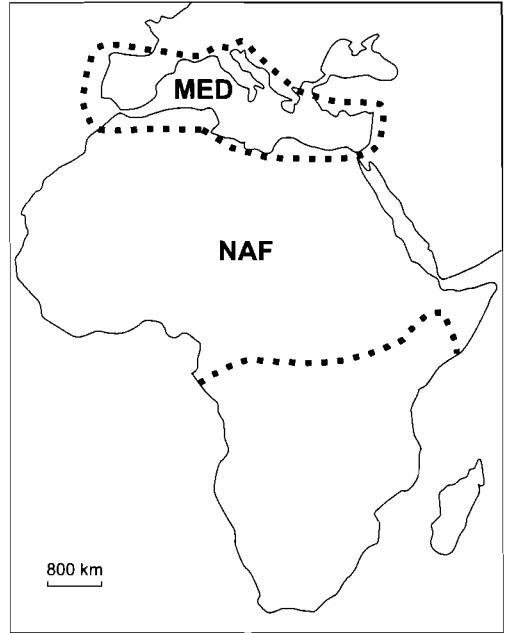


Figure 1b : MED and NAF zones
in the START/PIGB system.

The **definition** of ROSELT/OSS is contained in the terms constituting its name :

NETWORK : ROSELT/OSS is a set of observatories ; the network is concerned with exchange and cooperation between the observatories themselves, but also with the group which they form and which is in a turn a comprehensive observatory for the whole Oss zone.

OBSERVATORIES : each observatory represents a limited geographical area. It is defined by its specific objectives, which are two-fold in ROSELT/OSS : (1) to provide monitoring (**scientific and technical activity**), and (2) to produce results which are a decision-making tool for managers and development agents (**operational activity**).

ECOLOGICAL MONITORING : monitoring is based on a set of measurements and observations, and thus on repetitive acquisition of ecological data in the broadest sense, including socio- economic data interacting with the ecological data. The word " ecological " in ROSELT must thus be considered as covering all aspects of environment and of rural areas development (*s.l.*). Ecological monitoring is based in field measurements, complemented by remote-sensing data.

LONG TERM : the evolution of ecological and agro-ecological systems must be analysed over sufficiently long periods in order to explain the functional mechanisms; the considered time step is several decades. ROSELT/OSS also provides informations in the short and medium terms.

ROSELT/OSS : a tool for local, national and international purposes to apprehend the environment

Rationale for creating ROSELT/OSS

ROSELT/OSS is an integral part of the current strategy of the international community :

- **sustainable development**, which demands knowledge of the conditions to be filled to ensure long term integrity of the environment ;
- **global change**, which must be analysed both on a world-wide basis and also regarding significant local and regional changes ;
- **biodiversity**, which can only be qualified on the basis of local on site observations in relation to representative ecosystems, threatened species and populations or those in danger of becoming extinct ;
- **desertification**, which is a major issue of the Oss zone, particularly since the two major droughts in 1970's and 1980's, and considering the growth of socio-economic needs.

The commitments undertaken in relation to the above during or after the Earth Summit in Rio-de-Janeiro (UNCED, 1992) defined the measures to be taken : **Agenda 21, International conventions on global change and on biological diversity and the International convention on desertification** can only be applied with a good technical and scientific knowledge related to the evolution of ecological and agro-ecological systems.

In addition, ROSELT/OSS will provide **decision-making tools** based on the environmental status to managers in the various countries and sub-regions in matters concerning land and natural resources management.

Combatting desertification

An alarming situation

The geographic zone covered by Oss (**Figure 1a**) is most directly concerned by the problems of desertification since it includes regions that have become fragile as a result of arid climate and increased impact of human activity on the physical and biological environments. Drought is one of the primary natural causes of all the

processes that lead to desertification. It was exceptionally forceful in the Sahel during the recent dry spells from 1969 to 1973 and from 1984 to 1989. **The combined effects of drought and growing population pressure in Africa on the lands and plant resources have led to multiple dysfunctions in the ecosystems.**

The result is that the biological potential of natural ecosystems and agro-ecosystems have been drawn on beyond reason, and efficiently waters are becoming scarcer. Referring to considerable research work carried out to the north and to the south of the Sahara, Floret, M'timet and Pontanier (1990) stress that « *anthropic disturbances lead to scarcity of natural vegetation, soil degradation (water and wind erosion), deterioration of the land water use system and a decrease in the water use efficiency for plant production* ». The consequences of these disturbances, thus, impact biological resources and land potentials. They, in turn, upset the sequences of human activity, and ultimately cause people to abandon the land and emigrate to areas considered more hospitable. These problems are extremely serious for the local populations which cluster in the least arid areas, in particular in the driest parts of the sub-humid zones, and thus increase the risk of environmental degradation in formerly rather stable regions, and of impoverishment.

Actions carried out as part of global strategies to fight desertification, such as the ones derived from the “green belt” concept (UNESCO/UNEP/IRA, 1986 ; ACCT, 1987) have not been able to achieve their goals, apparently, first and foremost because of insufficient understanding of the processes underlying the dysfunctioning, and, in large part, because of the diversity of ecological, socio-political and economic situations. Many varied actions have been started. Some of them have been geared to ensuring a better fit between the potentials of the resources and the systems of using them in order to help the local populations and to avoid spreading the phenomenon encountered in the arid regions to the neighbouring sub-humid regions. After certain scenarios were staged to fight desertification, some situations occurred, as briefly described below :

- to make desertification less harmful, fodder shrub plantations have been established. They produce green fodder and timber, are useful in fixing sand dunes, and in controlling and curtailing water and wind erosion. But there is still a problem in choosing the best species (the problem of biodiversity) and resource management strategies for the various users (many references in Bognetteau-Verlinden *et al.* 1992 ; Baumer, 1987 ; Armitage 1986 ; UNESCO/UNEP/IRA, 1986).
- To make up for the shortage of water for the herds, boreholes have been drilled so that watering points can be made available in areas that have not yet been heavily grazed. This improvement in the use of groundwaters, in the medium-term future – if care is not taken – will cause very serious environmental degradation around the water points and will change the management of rangelands trekked by the migrating herds (transhumance). This can lead to relative sedentarisation and, then, overstocked grazing lands (Le Floc'h *et al.*, 1992 ; Durand, 1988, etc.).

- Irrigation projects have been designed and implemented to provide water in the oasis. Because of their topographic position, the irrigated areas often have problems of drainage and the inflow of saline waters. In the medium – term future, this can cause water logging and soil salinisation, or the degradation of the organic matter in the soil (Geny *et al.*, 1992 ; Mainguet, 1991 ; CIHEAM/CCE – DG VIII, 1990 ; etc.).
- Because of the increase in the demand for food crops and agricultural exports in zone stretching from the semi-arid savanna to the dry sub-humid area, following time has been shortened. Until the recent past, the fallow period served to restore soil fertility. Now, the soils are quickly depleted and the global biodiversity has been notably reduced in the savanna areas (MAB Digest n° 16, 1993, « *Fallowlands in Tropical Africa* » by Ch. Floret, R. Pontanier and G. Serpantié).

The need for networking

These examples show that a land development and environment management scenario can only be effective if it has a minimal scientific/technical basis. Its success also depends on social and economic acceptability. One way to tackle this problem efficiently consists of compiling and coordinating information on work done in countries that are committed to fighting desertification and in proposing ways to harmonize the methods being user or, at least, to make them compatible so that data and results from their experiments and projects are comparable and extrapolatable. This saves time and resources.

Most past studies and actions have been isolated, fragmentary and/or limited in scale. In many cases, resources have not been adequate. This fact has been ascertained by Oss and highlights the enormous difference between the ideal theoretical approach, yet to be further fathomed, and the objective reality. That is why Oss has launched the creation of a Long term ecological monitoring observatories network, and has called it ROSELT, the acronym of the name in French, Réseau d'Observatoires de Surveillance Écologique à Long Terme.

International concern

◆ ***The Conférence on desertification (Nairobi, 1977)***

It was at the 1977 U.N. Conference on desertification that, the first time, the extent of the desertification phenomenon in the world's main ecological zones was depicted at the international level. This all important phenomenon was defined as « *destruction of the earth's biological potential which will lead to the onset of desartic conditions* ». It was also shown that the destruction had many causes, but that the main ones were related to the impact of manmade activity.

Large amounts of international funding were allocated to the fight against desertification. The U.N. system earmarked over five hundred million dollars and

EEC, through the Environment section of the 4th Lomé convention in 1991, assigned fourteen billion dollars for a five-years programme for the ACP countries.

◆ ***The Oss conference (Paris, 1990)***

All the facts described above constituted the essential basis of the approach proposed by Oss at its launching conference in Paris in June 1990. Oss stipulated that « *man, as the source of environmental degradation, should also be the source of rehabilitation, all the while deriving the best for his subsistence* ». These statements were repeated at the 4th UNCED preparatory committee meeting in New York in March-April 1992 (U.N., 1992) and at meetings of the Intergovernmental committee for a convention to combat desertification (INCD).

◆ ***The Earth Summit (UNCED, Rio, 1992)***

The United Nations conference of environment and development, UNCED, or the Earth Summit devoted chapter 12 of Agenda 21 (= 21st century) to desertification (UNCED, 1992). Desertification is considered as a serious handicap to development since, at the planet-wide scale, it could affect some thirty-six million square kilometers of arid lands : « *desertification is the degradation of soils in the arid, semi-arid and subhumid zones as the result of various factors, including climatic variation and human activity* ».

◆ ***The International convention on the fight against desertification (Paris, 1994)***

Increased arid climate and the effects of human activity on the arid, semi-arid and dry sub-humid zones have been identified as the main causes for desert encroachment. **This situation has inspired the international community and, in particular, Oss as concerns the circum-Saharan area, to establish strategies for analysing, evaluating, preventing and parrying desertification and for finding solutions that are compatible with sustainable development in the regions affected by the dynamic processes.**

In compliance with the options selected at Rio, the draft final text, which was prepared in June 1994 in Paris by the Intergovernmental negotiating committee for a convention to combat desertification, responsible for drawing up the « **international convention on the fight against desertification in the countries worst stricken by drought and/or desertification, in particular in Africa** », spells out the strategies and means to be used by the international organizations and the targeted countries. The convention was signed in October 1994.

The convention gives priority to Africa and encourages cooperation between the countries and the sub-regional, regional and international levels, in particular in the field of science and technology (section 2, Articles 16 and 17). The parties to the convention intend to integrate and coordinate the collection, analysis and exchange of relevant short-term and long-term data and information to ensure systematic

observation of land degradation in the affected areas and to better understand and assess the processes and effects of drought and desertification. For this purpose, it is especially important :

- to facilitate and strengthen the functioning of a global network of institutions and facilities for information collection, analysis, exchange and monitoring at all levels, which shall, *inter alia* :
 - aim to use compatible standards and systems ;
 - encompass relevant data and stations, including in remote areas ;
 - use and disseminate modern techniques for data collection, transmission and assessment on land degradation ;
 - link national, sub-regional and regional information and data centres more closely with global information sources ;
- to support and further develop bilateral and multilateral programmes and projects aimed at defining, conducting, assessing and financing data and information collection, analysis and exchange, including, *inter alia*, integrated sets of physical, biological, social and economic indicators ;
- to give full weight to collection, analysis and exchange of socio-economic data, as well as their integration with physical and biological data.

As concerns R–D, the convention promotes scientific and technical cooperation in the fields of combating desertification and mitigating the effects of drought through appropriate national, sub-regional, regional and international institutions. To this end, it gives support to research activities :

- that contribute in increased knowledge of the processes leading to desertification and drought as well as the impact of, and distinction between, causal factors, both natural and human, in order to fight against desertification and to mitigate the effects of drought and to improve productivity, and sustainable use and management of resources ;
- that develop and strengthen national, sub-regional, and regional research capabilities in affected developing countries ;
- that promote the conduct of joint research programmes between national, sub-regional, regional and international research organizations.

Annex 1 of the convention concerns implementation at the regional level for Africa. It provides for the formulation of national and sub-regional action programmes and a regional action programme.

Oss as a transregional organization, and CILLS, IGAD and UMA as sub-regional organizations, met during the convention's preparatory phase in order to coordinate their input in action programmes and in efforts at scientific/technical cooperation falling within the purview of the convention.

The creation of ROSELT/OSS was a response to recommendations 16 and 17 of the International convention on desertification. This network, both at a local and global Oss zone level and by cooperation between observatories and countries, will ensure the most efficient monitoring of test-sites threatened by desertification and the study of the involved mechanisms. This means :

- identify the causes and effects of desertification through long term monitoring (monitoring activities) which should in particular allow the establishment of desertification indicators ;
- to understand the mechanisms leading to desertification which can be used to prevent them (research activities).

Figure 2 presents the principles of both types of intervention.

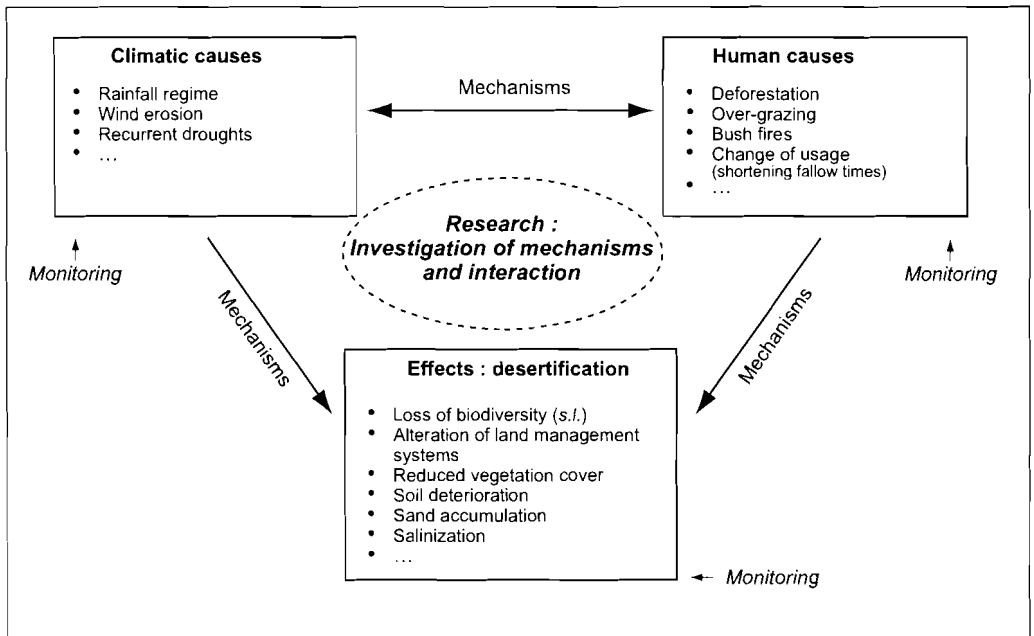


Figure 2 : Causes and effects of desertification.

Maintaining biodiversity (see also p. 35)

Biodiversity is fashionable in the universal conscience. Scientists have more than fully shown the risks facing humanity because of the present massive biological erosion. During the UNCED (Rio, 1992), an important step was taken when one hundred fifty-two nations, including the developing countries, signed the

biodiversity convention. « *The degradation of biological diversity which we are currently witnessing is essentially the result of human activity and seriously jeopardises the development of mankind* » (UNCED, 1992). The convention, in particular, recommends sustainable use of the elements that make up biological diversity by protecting and supporting the « *customary use of biological resources in compliance with traditional cultural practices* », and by « *helping local populations design and apply corrective measures in degraded zones where the biodiversity has been impoverished* » (UNEP, 1992). Because of their capacity for ecophysiological and genetic adaptation, numerous precious information for future use. In this context, the regional network (in the U.N. sense of the term) of *Biosphere Reserves* in UNESCO's MAB programme could provide a useful contribution since the existing biosphere reserves have conservation and monitoring programmes (Objectives 3 and 5 of the Action plan for biosphere reserves, UNESCO, 1984. The plan was renewed for the period from 1990 to 1995) and the existing network is still fragmentary, which means that in the near future, it could be extended to cover new territories suggested by the countries in the Oss area.

The study and monitoring of biodiversity in the ROSELT/OSS observatories is a means to accurately sample the original biological heritage in the arid zones around the Sahara, where endemism is important and a mosaic of adaptative and evolutive locations can be found.

Participating in the description of climatic changes (see also p. 33)

Another general reason to support the constitution of ROSELT/OSS is connected to the problem-oriented approach to planetwide climatic change, or global change, whose underlying hypotheses are being analysed as part of the International Geosphere-Biosphere Programme (IGBP) of the International Council of Scientific Unions (ICSU) and, even more so, as part of the START initiative (*Global change system for analysis, research and training*). This programme seeks « *to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human action* » (Eddy *et al.*, 1991).

The area concerned by OSS is considered by START/IGBP as a zone that is especially vulnerable to regional change on the one hand, because of the rapid increase in its populations' socio-economic requirements, and, on the other, because of the change in the use of resources and land areas in response to interannual climatic variability. Because of this situation, the Oss area is of high priority.

Furthermore, the desert fringes bordering the Sahara and the buffer territory between, the arid and humid zones are amongst the most sensitive to climatic change, which justifies the implementation of medium- and a long-term monitoring programmes that equip the national authorities to prepare measures for the resource

use and management systems. According to Cornet (1992), « *because of the effects to the overall climatic circulation, the degradation of arid zones plays an important role in global climate change, in particular by the changes it triggers in the albedo and the subsequent circulation of dust and aerosols* ». The objectives and method of interventions of the MEDIAS initiative (1992) seek to provide a partial response to this aspect of problems connected to desertification, « bringing together in a single network, the research centres, universities and organizations interested in studying the various aspects of global change ». MEDIAS covers the Mediterranean zones (MED) and the North Africa (NAF) region as indicated in the START/IGBP system (**Figure 1b**), while OSS covers the MED and the NAF regions *pro parte*. The geographic boundaries of the two START regions do not fully meet the ecological requirements of ROSELT/OSS as a network with *complex zoning, based on environmental characteristics, and not only on physical climatology but which also includes biological traits linked to various uses*.

The ROSELT/OSS observatories will provide at the sub-regional and regional levels information to explain climate related changes in terms of the atmospheric exchanges between large ecological peri-Saharan zones. In particular, land cover and its degradation play an important role in the evolution of terrestrial albedo; which in turn is related to climatic changes (see p. 35).

Participating in a strategy of sustainable development (see also p. 39)

The United Nations system, *inter alia*, the World Bank, UNDP, FAO, UNESCO and UNEP, as well as the international community in general, recommended application of the sustainable development strategy, which stems from two ascertained facts : each and every country is entitled to improve the standard of living of its populations, and, improvement can only be sustainable if it falls within the limits dictated by the environment from which it draws its resources. The Brundtland Report (WCED, 1987), as the productive outcome of work by the U.N. World commission on environment and development, defines sustainable development as « *development that responds to the needs of today without compromising the capacity to satisfy the needs of future generations* ». The concern for safeguarding the potential of our environment's renewable resources constitutes a limit to our use of the planet's assets.

It has been generally accepted that « *there is no model for sustainable development because social problems, economic systems and ecological conditions vary greatly from one country to the next. Each country has to find its own way* ». The concept of sustainable development, thus, is more of a decision support principle than a new economic system. Acceptance of this principle in economic decision making requires both a more general and a more precise outlook of the ecological systems affected by the decisions. Furthermore, ecological and economic problems transcend borders. « *No country can develop in isolation; sustainable development requires new orientations in international relations* ».

ROSELT/OSS is fully compatible with the principles of sustainable development since its purpose is to better apprehend the interactions between socio-economic systems and ecological systems, and to assess positive (improvements) and negative (deterioration) changes in the long term and in zones that are large enough and representative enough. In the event of negative change, corrective measures will be required in the implementation of resource and land management systems.

The concept of sustainable development was supported time and again at the UNCED in Rio in June 1992, and has been given pride of place in Agenda 21 (UNCED, 1992) and the conventions on global change, on biodiversity, and on fight against desertification.

At the international and intergovernmental levels, implementation of the UNCED proposals involves various processes for funding and cooperation. Mention should be made of the connections with the **Global Environment Facility (GEF)** that is administered jointly by UNDP, the World Bank and UNEP. UNEP is responsible for the GEF secretariat and uses scientific and technical expertise, through STAP, its Scientific and Technical Advisory Panel which is in charge of evaluating the relevance of the countries' project requests.

Providing decision making guidelines to countries and sub-regions

(see also p. 45)

The convergence of progress in our understanding with the ecological fragility of most peri-Saharan lands indicates the need to base decisions concerning the development or management of the environment on scientific knowledge.

This is all the more true in that these countries and sub-regions are since the Rio conference committed to environmental planning and programming, notably in combatting desertification : National environmental planning and programming, notably in combatting desertification ; National environmental action plans (NEAP) related to Agenda 21 ; national and sub-regional action programs (NAP, SRAP) in connection with the International desertification convention (IDC). Knowledge of the status and trends of environmental parameters (climate, flora and plant cover, land and water resources, crops, rangelands, forests, land management procedures, human pressure on the environment, etc.) is necessary for creating coherent programmes. Indeed, these programmes must also contribute to as prospective analysis of the environmental consequences of planned policies and actions.

At a more local level, the decisions concern the implementation of development projects which must take into consideration their environmental impact in both the short and long term. Field data must be available in the domains of ecology, sociology and land-tenure, with simulations to describe the interactions between development and environment; in this way, scenarios of evolution can be obtained that are based on realistic hypotheses.

ROSELT/OSS will provide tools for decision-making that affects the status and trends of the environment to each of the three sub-regional, national and local levels.

Such tools may be either raw data (with scientists to interpret them) or environmental and desertification key-parameters (produced in response to requests from decision-makers and relying on scientific data), or maps and thematic documents (see p. 43).

Goals of ROSELT/OSS

Based on the rationale behind the creation of ROSELT/OSS and on its specificity as a sub-regional and regional network, **nine goals** have been assigned to ROSELT/OSS by the participating countries and agencies :

- **to harmonize the scientific approaches** to ecological monitoring, data choices, systems of data selection, processing, and information retrieval and dissemination ;
- **to improve the knowledge base** on long term ecological monitoring ;
- **integrated processing of data collected** from all observatories so that an environmental status report can be periodically distributed together with environmental and desertification parameters for the entire Oss zone, by sub-regions, and by countries ;
- **to share information** between countries and between observatories ;
- **to help bring** environmental research and development activities closer together through actions in the field ;
- **to provide assistance** in training scientists and technical officers ;
- **to further the integration** of countries in the Oss zone in international programmes and strategies related to environmental protection and sustainable development ;
- to work towards **perpetuating** the network observatories thanks to appropriate institutional and financial procedures ;
- to apply **financial assistance** for the network observatories using a joint approach to the funding agencies.

Basic ROSELT/OSS products are characterized by their scientific and technical features. Accordingly, the scientific objectives of ROSELT/OSS must be detailed.

The forthcoming structure for Research (R), Research-Development (R-D), and Research-Action (R-A) will be designed to strengthen cooperation between countries at the regional and interregional levels, with backing from Oss, on the basis of national initiatives directed to problems of common interest, that exceed the national boundaries. **ROSELT/OSS, in particular, should make it possible to harmonize and integrate various activities and contacts in countries of the Oss area in order to pave the way for a regional perspective.**

It is being suggested that two objectives be put forth, each bearing its own goals and final purposes :

- **Baseline knowledge for long term ecological monitoring** : contribute to improving the potential baseline knowledge on the long term operation and development of ecological and agroecological systems including present and potential environmental imbalances that can affect the social and economic future of local populations, ecoregions and countries in the Oss area.
This objective will be achieved by integrating the data from ROSELT/Oss observation and measurement facilities into development models for countries or groups of countries.
- **Links between baseline knowledge and technical choices** : after having clearly defined the environmental problems, as well as the expressed motivations and needs, and considered the importance of developing coherent data collection systems and information processing, interpretation and dissemination systems, the next step will be :
 - to favour, in each country in the Oss zone, harmonised integrated collection of data considered necessary in order to apply the multidisciplinary approach that can provide explanations on the causes and effects of natural and manmade disturbances (connected to the degree of impact from human activity) ;
 - to precisely formulate the hypotheses to be tested, in order to produce the most appropriate information in an effort to reconcile environmental quality with long term socio-economic development ;
 - to integrate the data and information into models or mechanisms for ongoing ecological monitoring of environmental change.

ROSELT/Oss in the local, national and international context

At the local level, integrating research and development

The respective distinctiveness of development projects and research activities, even when carried-out on the same ground make coordination and harmonization between actors extremely difficult.

Indeed, time scales, the nature of inputs, even the languages employed are apt to be completely different. Nevertheless, efforts to establish links have recently been made on both sides : research leaders are now more concerned with the social aspects of research and developers are becoming aware of the need for scientific data to guide their work.

ROSELT/OSS benefits from favorable conditions to foster cooperation around its observatories :

- its teams of technicians, engineers and scientists work in the field and keep close to local populations and managers ;
- the data and information gathered can be directly used to derive impact studies, environmental potential analyses, and environmental evolution scenarios, even if they were not initially designed for these purposes ;
- socio-economic and land-tenure approaches complement the ecological approach and are part of the ROSELT/OSS spirit. ROSELT/OSS is already in conceptual terms mediating ecological and human systems. This aspect can be continued and enhanced by more active and specific cooperation with local development agencies.

Local developers also, when they deal with weakened environments, need advice and expertise. This is true for government technical services, foreign participants (NGOs and international agencies), and local associations in increasing numbers, such as women's associations and urban or village groups.

One of the ROSELT/OSS objectives is thus to boost contacts with local developers by promoting new relations between scientists and local populations.

Participating in conception and implementation of national policies of environmental monitoring

As concerns **institutional aspect**, the Desertification convention (ICD), recommends the creation of *National Action Programmes* (NAPS). In West Africa they are to be initiated through national forums. This recommendation is to be taken together with Agenda 21 which recommends that a *National Action Plan on the Environment* (NAPE) be drawn up to focus on sustainable development. Furthermore, several countries, as of 1985, created *national desertification control plans* and, with help from IUCN, national plans to protect the flora and wildlife (*national conservation strategies*).

Many countries are using a single approach or are combining these activities, e.g. the CILSS countries which met in Ouagadougou (Sept. 1994) and in Bamako (Dec. 1994) to prepare the basis for their national actions together. OSS is participating in the process, in particular by striving to harmonize new programming process with old strategies.

This national tendency is being encouraged by the funding agencies' decision to combine efforts and, in each country, (and with the said country's approval) select a lead funding agency to coordinate their activities in ICD implementation.

Several countries are preparing the institutional framework for environmental plans to be applied during the coming years. Projects that want sustainability from the start need to fit in with the planning process.

From the **technical** vantage point, several countries have already begun working on the definition and initiation of a national ecology/environment monitoring policy, *e.g.* :

- Tunisia and Morocco, (which explains why they suggested that ROSELT/OSS consider PCTS of such numbers that they constitute a veritable national network) and Egypt which seems to be doing the same ;
- several countries in West Africa, *e.g.* Niger, Senegal, and Mali, which are setting up national information systems on the environment, with backing from UNDP and the World Bank.

ROSELT/OSS has made it clear that during the first phase, it will only consider a maximum of three to four observatories per country and that other observatories would be examined during future phases. It has indicated that its goal is not to cover the full range of bioclimatic situations, the priority being to begin with a good sub-regional and regional cover.

The participating countries felt, however, that the method proposed by ROSELT/OSS (see report on Rabat workshop) was thorough and relevant enough to be use in networking ecological observatories, regardless of scale. The method can be applied at the national level just as well as at the sub-regional and regional levels. This explains the underlying reason to proposals that ROSELT/OSS also take account of the Tunisian, Moroccan and, to a lesser degree, Egyptian national observatories networks.

Because of the present context, many countries will include environmental monitoring in their national plans and approaches either by including it in the NAT themes or under other themes. ROSELT/OSS could be associated with this **national** approach but whether ROSELT/OSS is seen as a sub-regional or regional network that only labels a small number of observatories in each country, or ROSELT/OSS broadens its investigations in relation with some national networks.

Furthermore ROSELT/OSS does not have the capacity to label and open the network to include more than its present number of observatories without jeopardising its scientific (and logistic) quality, should the number of observatories drastically increase in the countries.

Given the actions that have been undertaken with CILLS, IGAD, UMA and Club du Sahel, as well as the interim secretariat of IDC towards South and North countries for an application to the convention on desertification (its efforts are directed, concurrently, at funders, political decision-makers and scientists), OSS must participate in national consultations but must also ensure that its activities match ROSELT/OSS resource. OSS management will examine ROSELT/OSS's response each and every time it is requested by the participating countries to help plan environmental monitoring. ROSELT/OSS should direct its actions to a small number of countries on an experimental basis as a first step.

ROSELT/OSS as an international motivations force

The OSS executive secretariat, on the whole phases with ROSELT/OSS, its actions with international initiatives related to ROSELT/OSS's objectives taken as a whole. This means that :

- ROSELT/OSS has started to harmonize methods with GTOS, and with PICB as a whole (cf. discussions with the ENRICH european network, Florence meeting, January 1995) ;
- ROSELT/OSS objectives and actions are in agreement with the IDC decisions (with particular reference to Articles 16 and 17), especially concerning the details of their application, as indicated in the Africa Annex ;
- ROSELT/OSS takes account and coordinates its actions with those of the networks and programmes that have similar objectives, *e.g.* RCS/Sahel, SALT, Jachères, North African Green Belt, MEDIAS, LISE/AFRICAGIS, SUDDAN...

With the support shown at the Rabat workshop by the representatives of FAO and UNESCO, the time has come for ROSELT/OSS to contact the other bodies in the **U.N. system** (UNDP, UNDP / UNSO, World Bank, UNSP, GEF) as well as **the European Union** and the ACCT (**Agency for cultural and technical cooperation**).

Under the supervision of the OSS secretariat, ROSELT/OSS takes care of the best compatibility between the national, sub-regional, and regional actions in the OSS areas with the strategies, programmes, projects belonging to CILSS, IGAD, UMA.

Several northern countries already contribute significantly to ROSELT/OSS : France, Italy and Switzerland. Information is going to be sent to the other countries of the North that are working on ROSELT/OSS observatories or might be interested in ROSELT/OSS's activities.

Figure 3 presents ROSELT/OSS's position in terms of the local, national, regional and international contexts.

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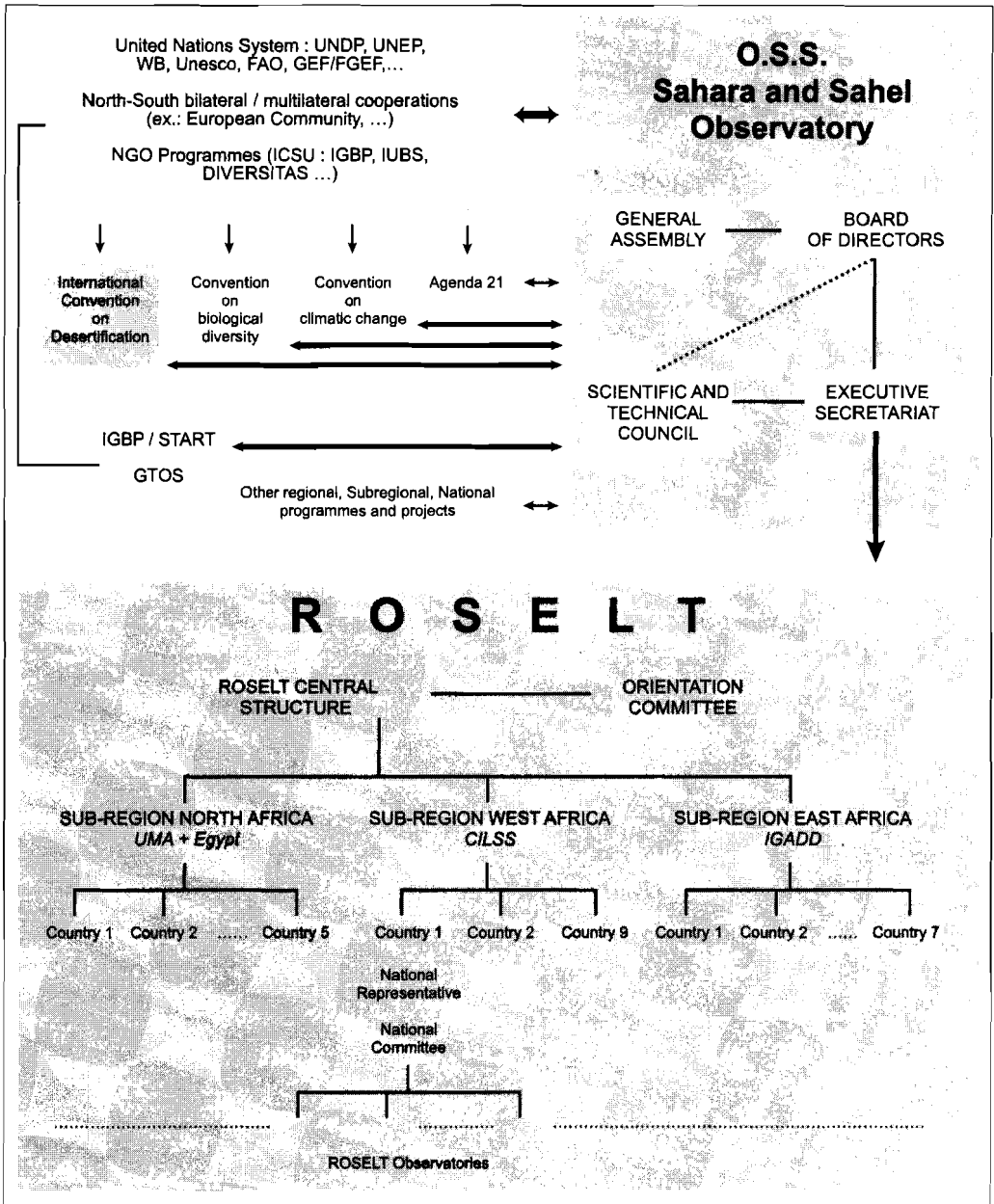
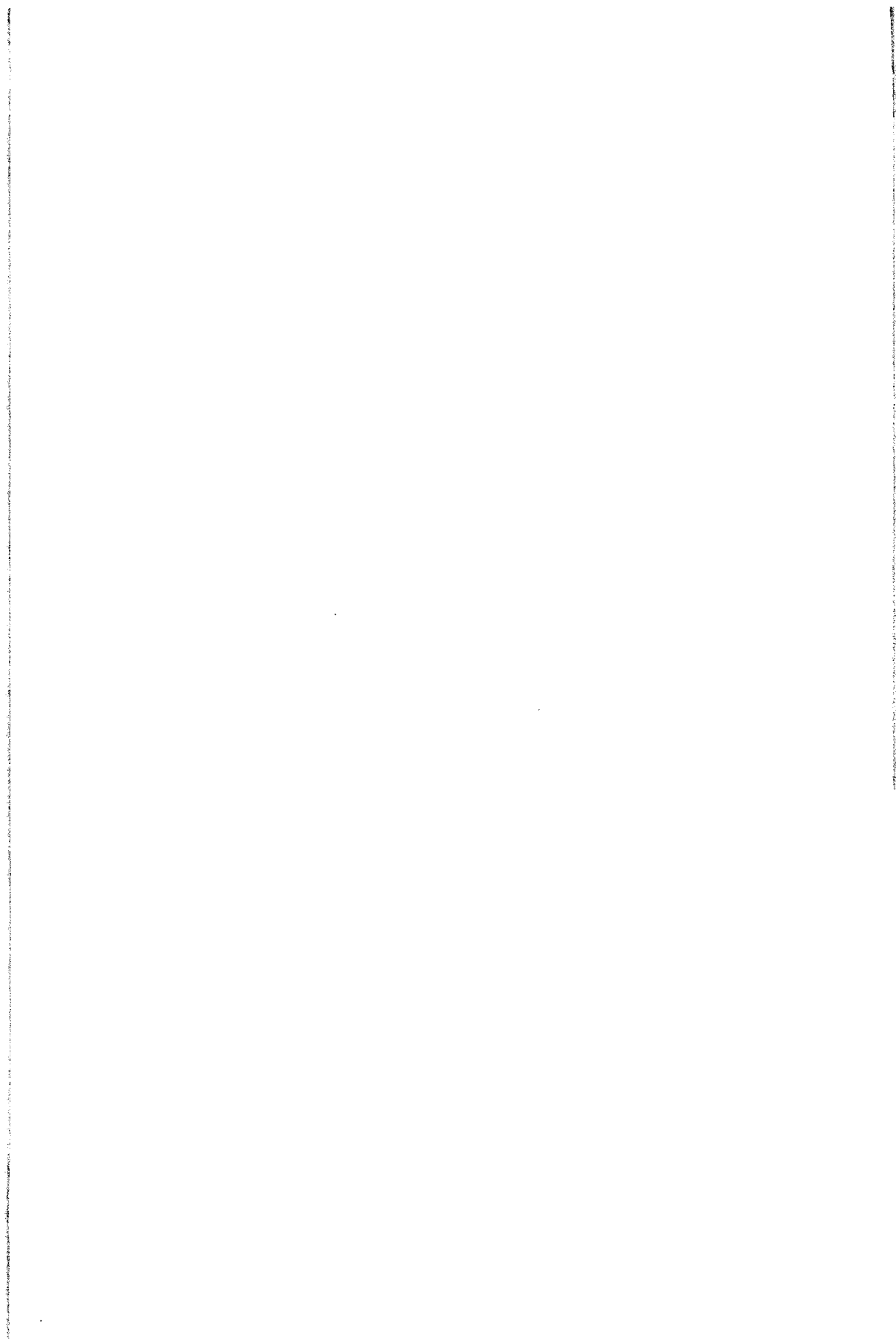


Figure 3 : Outline of ROSELT/OSS position in relation to the institutional international, regional, national and local environment.



Scientific, technical and thematic approaches

Scientific and technical approach

To reach its goals, ROSELT/OSS must define a scientific project that will serve as a reference for data harmonisation and collection procedures and for assessment of the degradation of ecosystems and agroecosystems. ROSELT/OSS must also provide national decision-makers and administrators with effective decision-support tools useful for development and natural resources sustainable management in the Oss zone.

General strategy

An initial obligation : scientific content and quality

The success of ROSELT/OSS activities will depend on sound scientific content and quality. This should be a very strict requirement for all levels of design and implementation because the reliability of the resulting products will depend on it. This applies equally to the unprocessed products that are provided as data and indicators on the evolution of environmental conditions, and the more elaborate products such as the ones generated by functional models of ecological systems agro-ecological systems, socio-economic systems or complex interactive systems represented by relations in time and space between the different systems or else critical analyses and summary reports to be used in decision support processes.

An appropriate sampling design

To achieve the aforementioned objectives, which involve global perception of processes and mechanisms, attention must be given to the problem of obtaining **representative data**. This leads to the question of the **relative heterogeneity of environments, resources and land use** in the Oss area. For the categories of variables that are to be sampled, it is important to have criteria that can reproduce the heterogeneity of the zone and provide complementary data for the sampling grid (zoning of bioclimatic systems, zoning of major land/soil units, zoning of human activity systems). **This requires a stratified, problem-oriented sampling design system for each level of perception of the phenomena being studied and for representative space and time scales.** The sampling work should be precise enough to provide objective, realistic spatial representation of data and results. Further, it should be designed to facilitate the application of a **data and information management system** that is both efficient and amenable to change without growing

obsolescent or losing its time-related quality. This requires a certain **steadfastness of institutions and staff responsible for data collection, storage and processing.**

In practical terms, the sampling procedure selected by ROSELT/OSS derives from a bioclimatic zonation, as presented in **annex 1** ; this zonation is based on criteria of latitude, aridity and the annual distribution of rainfall. **This bioclimatic zonation is associated, in each eco-region of each observatory, with an *ad-hoc* classification of human activities, land-holding and land use.**

For each geographical space unit selected via the sampling system, the most appropriate field observatory for the systematic collection of data, considering the level of integration being sought and the environmental problems, should be designed and installed. Each field observatory is located between the **terrain** level, (the source of relevant data on problems of ecological monitoring, and environmental management and development), and the **network** level, where these data are harmonized to avoid redundancy and increase efficiency, and where work is done to integrate them in time and in space.

This theoretical approach should serve in the selection of ROSELT/OSS observatories since the related procedure is based on a scientific/technical analysis, but it should give due heed to the position of the **existing observatories** which can be included in the network if they meet the scientific requirements and if a sampling strategy that is acceptable to the Oss zone as a whole properly adapted.

An integrated investigation system

Because of the diversity of the selected ROSELT/OSS observatories, the outcome will be an observation system that is integrated from the lowest observation level (site, biotope, cultivated field) via the vital intermediary levels (ecological landscape, main land forms, villagelands or *terroirs*, ecoregions, etc., see p. 30) to the level of the whole network. For each level of observation, different types of data have to be defined and justified (see **annex 2**). Generalised applications will depend on the possibility of generalising certain data or results from a lower level to a higher level. Consider the following sequence as an example : plant production that is useable at one or more sites → land areas covered by plant formations or types of ecological systems ; *per capita* consumption of shrub and/or pastoral resources from an ecological sector or a *terroir* → demography and needs of the local populations of the *terroir* under consideration or the ecoregion.

Compatibility between data and data gathering methods

A large percentage of the raw data collected as part of ROSELT/OSS have to be compatible with data obtained through other long term environmental observation networks or through programmes and projects with similar objectives. Harmonisation can ensure rationalisation and economy of resources. This work

should be done through international discussions on methodology, in particular on proposals that refer to GTOS and which Oss contributed to or sponsored at the Fontainebleau conference (Heal *et al.*, 1993). It should be carried out in total synergy with the other Oss programmes and, in particular, ISE and SUDDAN. Duplicating the MEDIAS activities must also be avoided.

Definition and purpose of a ROSELT/Oss observatory

General definition

An observatory is defined, technically, via a system (figure 4) for collecting and processing environment-related data on a given ecological or agro-ecological unit. It is a response to a demand for decision support products, which are identified by the national decision-makers and administrators for a given integrated spatial level (landscape unit, sub-region, region).

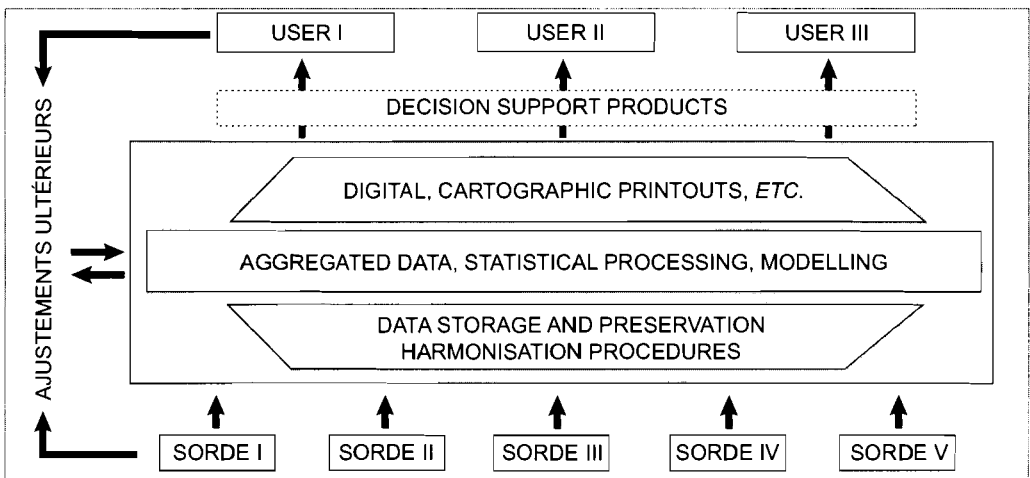


Figure 4 : Outline of the functions of an observatory,
adapted from IARE, 1993

(SORDE : *Système d'Observation et de Récolte de Données sur l'Environnement* – system for environment related data observation and collection).

It can include sites (biotopes, ecotopes) or cultivated plots which are used for general and/or specialized observation work, and are designed and implemented to respond to environmental problems in long term monitoring of the evolution of ecological and agro-ecological systems.

The ROSELT/Oss observatories collect various types of data, *biological, ecophysiological, climatological, pedologic, agronomic, sylvicultural, economic, sociological, demographic*. But they are all collected using comparable protocols. This ensures a certain harmonization of output and essential compatibility within the network.

This general definition of an observatory can be broken down, into two main types of SORDES : statistical and scientific.

- a) The first type is **mainly statistical in nature and is used for general application**. It is designed for use in routine monitoring of the state and evolution of resources and space, with reference to all the compartments of socio-economic activity that are directly or indirectly affected by environmental conditions and by problems of land development and resource management ; this **type of approach is analytical and statistical**.
- b) The second type is **mainly scientific and technical in nature**. It is designed to satisfy the need for knowledge and understanding of dynamic, evolutive processes that are clearly based on well exposed environmental and development problems, the follow through of which is justified by the present or probable contribution to environmental deterioration connected to current or foreseeable natural phenomena or human activity. This **type of approach is systemic and problem-oriented**.

Goals

A ROSELT/OSS observatory is defined in terms of the missions that it can carry out and the level of ecological integration referred to in the data it collects. Its operations must respect the general concept of sustainable development which implies optimal use of natural resources without compromising the biological potential for the generations at come. A ROSELT/OSS observatory will have **five missions**, but some of them, in particular c) and d) fall within the scope of activities that are most specific to other partners (see development projects).

a – Monitoring natural resources

The **primary mission** is long term (several decades) monitoring of the evolution of natural resources in the targetted zone. The aim is to provide constantly updated critical analyses of these resources and keep track of tendencies for them to change. Emphasis will be planed on renewable resources which are considered as the identifiable part of productive ecological and agro-ecological systems. This in no way deters ROSELT/OSS from focussing interest on certain wild genetic resources (see e)

b – Monitoring the uses

The **second mission** of a ROSELT/OSS observatory is to monitor the evolution of human activities that affect the lands under ecological and agro-ecological observation. The aim is to provide quantified, evolutive data on production operators, production and uses, and, thus, to determine trends of change.

c – Restoring resources

The **third mission** of a ROSELT/OSS observatory is research into rational solutions to the problem of restoring biological resources in ecosystems that have been

exceptionally affected. It is worthwhile monitoring what happens to experiments in controlling run-off waters, improving water use efficiency and economy for the purpose of obtaining an efficient water/biological production ratio, experiences with exclosures, reseeding of rangelands, treatment of soil surfaces, tree and shrub plantations, etc.

d – Efficiency : resources vs uses

The **fourth mission** of a ROSELT/OSS observatory is to define the optimal carrying capacity in given types of ecosystems or villagelands (*terroirs*), for varying time periods, and in relation to a specific type of use or multiple uses. The purpose is to conduct continual research on the conditions that ensure optimal efficiency of human activity, without running the risk of deteriorating the biological potential and without reaching irreversible threshold in the dynamics of the ecological system. Determining the optimal threshold for human activity is a priority objective when the observation site, as such, becomes the prime focus of a development project. The monitoring of management systems concerns this type of a mission. Research into the efficient social and economic use of resources should not be considered as counter to the environmental integrity of the areas of study (orientation n° 2 of the MAB programme and, *inter alia*, Young, 1992).

e – Forecasts for long term ecological change

The **fifth mission** of a ROSELT/OSS observatory is understanding the functional mechanisms of ecosystems and agrosystems. The goal is to be able make a long term forecast on how biological resources will change by testing various scenarios related to changes in climatic resources, socio-economic purposes and needs for the local populations (principle of self-reliance and endogenous development). This forecast ; by providing data on the most appropriate adaptations and preventive measures, will help administrators, developers and decision-makers prepare for future risks.

Further, the fifth mission could also aim, insofar as possible, to preserve the conditions in which the biodiversity evolves naturally. Tangible expression of this objective could be achieved through the existence of a network composed of several “ reference sites ” that would measure the degree of degradation/restoration of the various biological components of a landscape unit, and determine the conditions that exist when species evolve in their natural habitat or in a habitat little affected by man. These “ reference sites ” would also serve as warning and monitoring systems. Hopefully they could provide justification for what is commonly known as the “ core zone ” of the ten, or so, MAB biosphere reserves that are in the OSS region.

Relevant data

An indicative core list of relevant data is given in **annex 2**. It contains data on the general characteristics of the collection site and the various themes being studied in order to analyse ecological systems, resources, and uses : *the general and local climatic conditions, exceptional atmospheric events specific to the arid zones,*

characteristics of the flora and fauna, key factors of biodiversity, the condition of the soil surface, soil conditions, elements affecting the biological activity in the soil, the impact of biological invasions that have catastrophic effects, the impact of human activity, the social conditions, and the economics of production and manmade systems.

These different data sets are gathered within the framework of ROSELT/OSS using comparable protocols, which ensures both different types of harmonization of the outputs and an essential compatibility within the network.

The ROSELT/OSS data collection method is phased with the methods of other programmes and potential users, e.g., other OSS programmes, GTOS/IGBP, CEPE/CNRS, MAB, TSBF, ORSTOM, CIRAD.

Certain data, such as the data on the nature of the condition of the soil surface, burning of the plant cover, edaphic aridity, activity of earth dwelling animals such as termites, are more or less, specific in the OSS area. Therefore it is not surprising that they are not included in other international proposals here more attention is given to environmental change in areas where water is not the main constraint.

Field handbooks on problems that ROSELT/OSS will be solving might be produced, if there is a felt need. One example is what was proposed by CEPE/CNRS (Godron *et al.*, 1968) in order to harmonize methods for collecting phyto-ecological data.

Spatial design and sampling intensity

The observation sampling design should integrate multiple ecological, agro-ecological, and socio-economic data stemming from different environments and usages. It relies on a sampling systems structured into three levels of spatial perception, as follows :

- a) the ecological **site** : acceptable equivalents : ecotope, biotope ;
- b) the ecological **landscape** : acceptable equivalents : land system, dynamic geomorphological unit ;
- c) the **ecoregion**.

To simplify the presentation, no precise distinction is made here between the levels of spatial perception that separate agrosystems and ecosystems, often considered as " natural " systems. But it is no doubt useful to point that the *site* corresponds to the *cultivated field* or the *plot*, a unit of agricultural production and that the *ecological landscape* or *land system* correspond to the *terroir* (villageland) or *farming system* and the *ecoregion* corresponds to the *agroclimatic* or the *agricultural region*. These three basic spatial levels are referred to through the corresponding terms of *site level*, *landscape level* and *regional level* (or *scales*) in various international programmes such as LTER (Long term ecological research) in the United States and GTOS (*Global terrestrial observing system*) that was proposed jointly by OSS, IGBP (GCTE : *Global change and terrestrial ecosystems*) and UNESCO / MAB (Heal *et al.*, 1993).

The site, thus, is the basic unit that corresponds to the most common level of field data collection (Figure 5). At the level of the ecological landscape, series of sites and their modes of liaison can be identified, bearing in mind the various major resources and uses. Site distribution, and their observation and sampling design are determined according to a mode that accommodates the heterogeneity of environment, and the type and intensity of measurements being sought. Transects are often effective to study heterogeneity along a gradient.

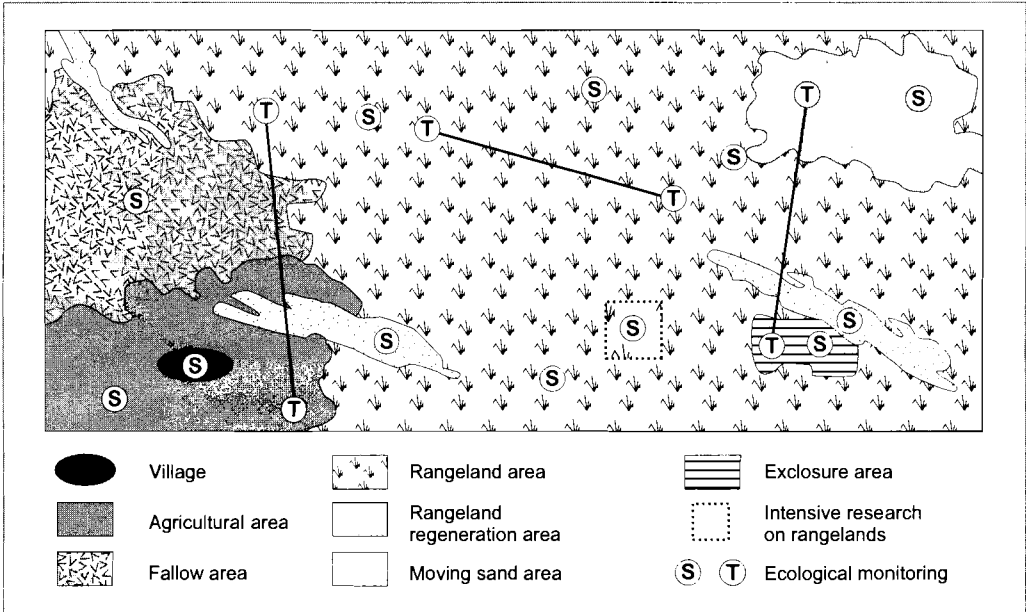


Figure 5 : Different ecological and agro-ecological sites of a landscape to be sampled using the site (S) or the transect (T) layout or design.

For each of the three spatial levels under study, observations are made with differing degrees of intensity, on representative samples that may include several levels of sampling but the basic level will always be the site. The types of data and precision of measurements depend on the level of perception being considered. Data will be generalised at the inter-site level according to an appropriate statistical mode, and the territorial size and horizontal structure of the units being studied.

At the higher levels (ecological landscape, ecoregion) data that come from remote sensing of satellites (NOAA, LANDSAT-TM, SPOT, etc.) and from aircraft will also be used. This has already been recommended in various international programmes on the perception and analysis of environmental change at the planet level, or at the continental or regional level. This a common option for the promoters of IGBP, MEDIAS and AFRICAGIS and in the CORINE LAND COVER project, an EEC initiative that may be extended to Africa (started in Morocco and Tunisia), as well as in the OSS SUDDAN programme.

Three levels of intensity of observation and measurement are being considered, as per the GTOS recommendations (Heal *et al.*, 1993) :

- a) an **extensive level** which, for ROSELT/OSS, corresponds to long term monitoring of the evolution of resources and traditional uses; for GTOS it corresponds to spatialisation of data ;
- b) an **intensive level** which, in the ROSELT/OSS system, corresponds to research on thresholds of ecological rupture, and optimal efficiency between resources and uses, for GTOS, the study of ecological gradients ;
- c) a **very intensive level** which, for ROSELT/OSS, corresponds to research on the mechanisms involved in the functioning and evolution of ecosystems and agro-ecosystems.

This distinction of level of observation intensity and measurements also corresponds to a division of scientific activity in keeping with the various missions of an observatory (see p. 28.). **Thus for each mission that it has selected, a ROSELT/OSS observatory can play a significant role in the network, without having to be capable of all the potential scientific and technical activities suggested by ROSELT/OSS's list of missions.**

This is an illustration of OSS's commitment not to exclude from ROSELT/OSS thus the will of the ROSELT/OSS designers will be heard. They did not want to exclude the local or national partners who were not sufficiently prepared to cover the **whole range** of ROSELT/OSS missions but were desirous of participating if gradually building up and implementing the system.

Potential thematic approaches within ROSELT/OSS

Introduction

ROSELT/OSS's strategy considers environmental problems that exist at the planetary, continental (Africa), or regional (peri-Saharan arid zone) levels, and that pertain to the **general topic of land degradation**, with among other **consequences encroaching desertification in arid lands** and related **poor development**. More specifically, this strategy **promotes and supports already existing programmes and projects that can meet information needs**, using long-term monitoring of test-zones which are both ROSELT/OSS observatories and zones under development where actions are compatible with environmental protection. **Three major themes** are involved :

- ROSELT/OSS and climatic changes,
- ROSELT/OSS and biodiversity,
- ROSELT/OSS and sustainable development.

The **officers in charge on the coordinators** of the various ROSELT/OSS observatories will identify programmes, projects or actions either in the recent past or presently being carried-out, whose objectives, data and results are compatible with ROSELT/OSS strategy, with ROSELT/OSS reserving the right to minor adjustment or complementation. The purpose of **thematic programming** is mainly addressed to prevent or combat desertification through decisive measures to reverse the present negative trends. This can be accomplished by encouraging the natural recovery of biological systems, their capacity for self-regulation, protection, and production and the sustained improvement of all factors contributing to the economic and social development of the test-zones under ROSELT/OSS strategy.

Since trends due to natural constraints – physical as well as biological – and trends derived from related human activities are not neither the same nature nor intensity in the various arid Oss sub-regions (*i.e.*, the northern Sahara under Mediterranean climate ; East Africa with tropical climate and bimodal rainfall regime ; West Africa with tropical climate an monomodal rainfall regime), the initial approach will consider separately the proposals in each major sub-region.

The themes will obviously be similar, as well in great part the procedures and methods utilized in the studies, with major efforts towards standardization.

The only fundamental differences will concern the contents (ecological systems, agro-ecological systems, and interacting socio-economic systems) and the speed of change in reaction to natural or human induced stress (for instance, in the case of development actions or when fighting desertification).

Therefore, ROSELT/OSS's strategy is to contribute in deliberate fashion to the **understanding of environmental phenomena** whose positive or negative consequences are mainly perceived at the **local level** (*i.e.*, within the areas considered as ROSELT/OSS observatories, and neighbouring representative areas) but which may also be perceived at **other levels**: national, sub-regional, regional subcontinental, or international.

ROSELT/OSS and climatic changes

◆ *Land degradation* (desertification) is a major environmental event affecting arid lands in the peri-Saharan Oss zone. An increase in the negative consequences of degradation or their possibly even land improvement will induce, with different time scales, variable and contrasted changes in the terrestrial albedo. This last a parameter that may play a role in atmospheric exchanges with surrounding ecological zones close to the Sahara, or even with distant zones (*cf.* oceans).

ROSELT/OSS observatories can provide data – often gathered for other purposes – which, when analysed over long enough periods (several decades), **can explain the significant changes in albedo**. Indeed, the evolution of albedo, of prime

concern to climatologists and atmospheric physicists, depends in turn on the **evolution, in space and time, of the components and status of land surfaces**, components and measurements (see *annex 2*) dealing with :

- the nature, importance and functioning of **plant cover**, including its spatial and temporal (seasonal, inter-annual) changes, and its influence on the evolution of land-cover criteria ;
- the nature, importance and spatial/temporal variability of **ground surface status and of the water content in the soil layers** which can be reached by roots.

ROSELT/OSS observations and measurements will be made with the appropriate procedures, using stratified sampling to take into consideration all major types of ecosystems, plant communities, farming systems and bare ground or poorly vegetated areas. Associating ground surveys and remote-sensing will facilitate the validation of retrieved data over larger areas.

◆ *The contribution of arid lands to the more specific topic of reducing carbon emission – a world concern for the coming decades – can be studied by relevant measurements dealing with the **inputs of the woody plant layer** (trees, shrubs and forbs) and **fiber plants** (perennial grasses, palm trees) to the production of plant **resources used as fuel for domestic consumption** (cooking, heating) **and for handicraft** (bread production, pottery, etc.). A few sites may also be devoted to studies on **burning** steppes and savannas, even scattered woodlands.*

In all cases, the work implies appraising and monitoring the **standing phytomass** and measuring the **masses cropped for various uses or social practices**. It should be noted that such measurements may be useful for other purposes (see p. 37).

◆ *The contribution of arid lands – sampled from ROSELT/OSS observatories test-areas – to **carbon capture and accumulation** is another aspect of the general topic concerning climatic change. Although their contribution is *a priori* deemed to be low compared to that of high rainfall zones, it must be detailed in terms of the present or potential capacity of ecological and agro-ecological systems to increase the standing biomass (plant material above and below ground) and even the living or dead organic matter in the soils. An increased mass, due to more carbon dioxide available for photosynthesis, is related to the **improved efficiency of the photosynthetic organs of plants ; the efficiency is linked to specialized plants** (cf. adaptations) **in arid lands** that can optimize water use (cf. optimizing methods) and improve the accumulation of photosynthetic products and the conservation of the produced material. Measures must record **all manifestations of increased woody biomass** (trees, shrubs, forbs), **fiber biomass** (perennial grass) **and above or below ground organic material**. All ROSELT/OSS observatories must introduce, in their “agenda” of planned operations, measurements of accumulated plant material expressed in a first phase by weight (kg, t) of dry matter per unit area, for each eco-agroecosystem. The measurements will be obtained with different time scales according to the management/utilization systems, and/or depending on rates of increase as related to cropping which fulfills the needs of populations. Of particular*

interest are the programmes intended for **reforestation, shrub plantation for browsing, dunes and sand-fixation, green belts, steppe and savanna rangelands rehabilitation, fiber production** (esparto grass), **fruit-tree plantations included in dry-farming** (olive, almond trees), **and irrigated systems** (oases).

Data on plant biomass will be all the more valuable when accompanied by **data on water efficiency for plant production** left on the ground or cropped, from natural or cultivated plants, and by data on recycling and accumulation in the soils.

Thus will the topic be examined, keeping in mind the need for **efficient conservation of soil and water** to ensure optimal utilization and improvement over the long term.

ROSELT/OSS and biodiversity

Generally speaking, arid lands have not to date received the necessary attention concerning their contribution to national and international conservation, protection and biodiversity preservation strategies. This is especially true for peri-Saharan Africa. The botanical and zoological past of Sahara, a long period of increasing aridity, shows adaptative and evolutive processes which are expressed by the present specific **genetic heritage and endemism** at both higher levels (family, genus, species) and within species (populations, ecotypes, varieties, races forms, etc.). In simple terms, the peri-Saharan zone exhibits **a mosaic of adaptative and evolutive** areas, similar to those commonly found in island systems (cf. Cape Verde) because of relative isolation. This **scattered of fragmented habitat** is somewhat masked by the presence of widely distributed, often dominant, plants that give a general impression of “standardization” of the vegetation. This impression is an expression of our ignorance and stresses the past scientific deficiency in this field (biology of conservation).

◆ *ROSELT/OSS observatories* at least some of them offer an opportunity to accurately sample this biological heritage. In addition to **listing the current plants** and critically evaluating their **vulnerability** (cf. red lists), ROSELT/OSS will focus on the **role** of such plants in the communities, ecosystems, and agrosystems to which they belong. The main effort will consider the **functional aspects and evolutive roles of species groups of highly meaningful bio-indicators** to evaluate biodiversity and its long-term conservation potential.

◆ *Studies on biodiversity* within ROSELT/OSS will develop from the precise identification and evolutive mapping of the **types of land use or habitats (biotopes)** most apt to increase biodiversity. Special attention will be given to arid areas that have obtained or may obtain status as a **protected area** (national parks, reserves, protected biological zones, biosphere reserves, etc.), to contact zones between biota (Mediterranean-Saharan, Saharan-Tropical, and so on) and to particularly **sensitive zones** (refuges for plant or animal species, humid areas surrounded by arid lands).

◆ *The standard phyto-ecological and zoo-ecological studies, which are usually necessary (cf. p. 37 and annex 2), will be most often accompanied by investigations on population dynamics, ecological genetics, and functional and evolutive ecophysiology).*

◆ *The ROSELT/OSS programmes related to the management and development of biodiversity must take into account these requirements in a long-term approach, in accordance with the recommendations of specialized IUCN and U.N. agencies.*

◆ *All the territories covered by ROSELT/OSS observatories have been undergoing the effects of a very strong human impact for millenia with the exception of Cape Verde, which has only undergone these effects for four to five centuries ? Up to recent decades, the impact has reflected **social practices linked to natural resources** and to the more or less autonomous capacity for adaptation and evolution of plants and wildlife. Of course, the arid lands around the Sahara have also benefited over millenia from exchanges with neighbouring ecological zones. As a result, **local people in the arid zone have appropriated a large stock of cultivated crops** (grains, fruit trees, etc.) and **suitable livestock** (sheep, goats, cattle, camels, etc.). ROSELT/OSS observatories will, when appropriate, **focus on this introduced biological heritage**, just as they will focus on **wildlife protection and medicinal plant conservation**.*

◆ *In addition, ROSELT/OSS must favour the elaboration of development programmes which include biodiversity as an objective considered to be as important as any other. Biodiversity can be encouraged, for example, by a sustainable use of biological resources in crop-livestock systems adapted to local environmental conditions and the needs of nomadic or settled people. To that purpose, **the concepts of landscape ecology and integrated rural development** will be the underlying principles of ROSELT/OSS. Lastly, a thematic approach to biodiversity cannot neglect **land-tenure systems, the status of protected areas, and biodiversity management as a whole**.*

ROSELT/OSS and sustainable development

In additions to ROSELT/OSS's contributions to strategies dealing with **climatic change and biodiversity and to strategies for sustainable development in line with AGENDA 21** (cf. Rio, 1992) most ROSELT/OSS observatories will build their programmes around activities directed towards **economic and social development, and towards fighting desertification**.

The themes may, accordingly, have **sectorial** or more **complex** aspects, depending on whether development goals concern **simple land use or multiple-purpose utilization of resources and space**.

Arid lands undergo climatic constraints (cf. aridity, droughts), **geomorphological constraints** (wind erosion, water erosion, soil dehydration), **and man-made disturbances** (impact of biological resources utilization and land use : excessive wood cropping, steppes and savannas turned into fields, cultivation with inadequate techniques, shortened fallow periods, overgrazing, etc.), all of which may produce land degradation (desertification to the point of irreversibility).

A strategy of monitoring and study in arid lands that is compatible with sustainable development **must keep as a guiding principle that three groups of criteria and/or indicators need to be simultaneously evaluated or measured by ROSELT/Oss observatories** :

- criteria and/or indicators to measure and maintain long-term environmental integrity ;
- criteria and/or indicators to measure the economic efficiency of production systems (in terms of output and services), integrating external costs ;
- criteria and/or indicators able to describe social and intergenerational equity in the long-term social evolution, at local and national levels.

In order to ensure a useful and efficient ecological monitoring of the concrete territories that serve as ROSELT/Oss observatories, a continuous evaluation of development achievements and environmental status must be produced. Thus, the sites devoted to **observation, measurement, and the analysis of the relations between resource and resource use** systems must be adapted to the various **economic and social situations**, either traditional, modern, or mixed. Such situations will in any case be modified by the evolution of **internal factors** (successive levels of resources, demography, increased competence of people, changing needs in goods and services, etc.) and **external factors** (trade, marketing, national or international policies, global environment, and so on).

The thematic approaches will be **systemic, integrated, and dynamic** ; they will clearly consider the different levels of understanding in the **relations between ecological and technical/sociological components** by focusing on the functional and **evolutive aspects**, and the **thresholds and limits** of the associated complex interacting systems.

The major themes are as follows :

- (1) Management and development of woody resources ;
- (2) Management and development of fiber plants ;
- (3) Management and development of rangelands and livestock ;
- (4) Management and development of crops ;
- (5) Sand encroachment prevention and fighting ;
- (6) Management of wetlands in an arid lands context ;
- (7) Peri-urban systems.

Management and development of woody resources

Woody resources can contribute to livestock and crop production (cf. p. 39). They can also be considered in the following terms :

- their role in accumulating and storing carbon (cf. p. 32) ;
- their role in live-sand fixation (cf. p. 40) and ground protection *sensu lato* (green belts, wind protection, etc.) ;
- their role in fuel or, less often, timber production.

In all cases and according to the traditions in most countries of the Oss zone the forestry scientists and technicians are in charge of studying and monitoring the **woodlands and forests**, as well as of their management and development, preferably in cooperation with local people.

The matter requires more skill when it concerns woody resources cropped from **trees and shrubs in the rangelands**, because observers and managers of these systems are more narrowly concerned with the relation between the pastoral resources and the need for livestock feed, rather than by the contribution of woody plants, even though the resource is obtained at the expense of the system's integrity in the long term.

In addition to measurements of plant material accumulation and the proportion that can be cropped, ROSELT/OSS investigations will include precise measurements of material actually cropped and used by local people. To satisfy environmental criteria of sustainable development, cropping must obviously be restricted, in order not to weaken the regeneration potential (resilience) of production ecosystems, and to comply with exploitation standards (rotational cropping, partial cropping, clearing for regeneration, reforestation, and so on). Replacing such woody resources, which are mainly for domestic use, by other renewable energetic resources, especially solar power, is worth considering.

Complete protection (in enclosures) over long periods certainly does not appear to be an advisable solution to ensure the conservation and viability of woody plants. Indeed, too large and increase in tree density may require water and nutrients in excess of the existing potential, with the risk of destroying the tree population in the case of recurring droughts.

Management and development of fiber plants

This section deals with fiber plants, namely perennial grasses such as *Stipa tenacissima* (esparto grass) and *Lygeum spartum* in the steppes of the North Africa highlands (Morocco, Algeria, Tunisia), or *Stipagrostis pungens* and *Panicum turgidum* in the hyper-arid Saharan zone. **Industrial use is exceptional** (paper from esparto grass) and still absent from the present local economy ; the standing crop of fiber plants is mainly used for **domestic and handicraft needs**, less often for livestock

(because of their low feeding value) or as household fuel. Observations and measurements will quantify the various off-takes and utilizations.

However, these plants have a paramount role in **soil conservation**, and are an important component of systems to prevent desertification. ROSELT/OSS observatories will aim at collecting the relevant data to evaluate the interest of fiber plants in **local development models**.

Management and development of pastoral resources and livestock

Most ROSELT/OSS observatories envisage this theme. The topic requires an improved **knowledge of rangelands**, and descriptions of **social practices, livestock management systems**, and **complementary feeding** from range reserves (browse), crops or marketed products. It must also include the **impact of wildlife** (ruminants) on rangelands, showing when applicable the adverse consequences for livestock ; it is also related to **soil conservation** (erosion through overgrazing and trampling) and **water conservation** (run-off, livestock water consumption).

Observations and measurements on rangelands will characterize ranges types (as part of land-cover mapping), with analyses to describe their functioning, productivity and evolution. Devices designed to evaluate and **monitor pastoral resources** will show the pros and cons of different **management systems**, and the contribution of pastoral resources based on different livestock systems to people's needs and to trade. Studies may consider aspects of **range rehabilitation** for example, where range/land degradation has been intense during recent decades, yet without reaching irreversibility thresholds.

Relations between **settled livestock** and **transhumant livestock** (nomadism) may be part of the proposed monitoring activities.

Management and development of crops

A distinction must be made between **cropping systems** based on **dry-farming** (grains and fruit trees as rainfed crops) of a **rather extensive type** and systems where **water is not limited to rainfall** (watered crops, irrigated crops, oases, **run-off farming**) and which are **semi-intensive or intensive**.

ROSELT/OSS observatories in cultivated land (cropping systems) will precisely record the crop types, utilized techniques, rotational systems, yields, needs for water and nutrients, and the contribution of cropping techniques to water and soil conservation of their impact on land degradation (erosion, loss of fertility, salinization, etc.).

Many models to describe the functioning of cropping and agricultural systems in the African arid zones have been generated and widely popularized in the Oss countries through programmes run by agricultural research institutions in

cooperation with counterparts from other countries or as part of regional development projects. ROSELT/OSS observatories will follow a similar strategy of cooperation and partnership.

Cultivated land degradation will be particularly monitored by ROSELT/OSS observatories. This degradation may be a consequence of an incorrect application of cropping techniques, leading to an increase in erosion hazards and soil salinization and a decrease in fertility (when, for instance, fallow periods are shortened). Poor irrigation water management may result in water-table salinization when the pumping rate is too high, or to soil waterlogging when the drainage is faulty.

Particular attention will be given to a conservative utilization of deep water resources, know for limited replenishment rates or complete absence of reconstitution (fossil water). In such situations, experimental procedures will be necessary to encourage **water-efficient cropping systems** (cf. winter grains instead of summer grains or cotton, under the arid Mediterranean climate).

The complementary of intensive cropping systems and dryland cropping will be examined in the framework of a **comprehensive approach to rural development in all areas of the ROSELT/OSS observatories**.

Preventing and fighting sand encroachment

Wind erosion is specific to arid lands, especially when the geomorphological substrate is weak with a dominant loose structure and a sandy texture, poorly protected by diversified vegetation covers or when a combination of climate and the strength of dominant winds favours deflation, transportation and accumulation of sand. Such natural phenomena are obviously accentuated by human activities.

Monitoring the **functioning and dynamics of sand** is an integral part of ROSELT/OSS's activities in observatories where sand encroachment is high. Reclaiming areas that have been or still are encroached by sand, and that have an obvious strategic value (agricultural development schemes, roads, settlements, etc.) requires special care and justifies data collection to establish indicators for the success or failure of sand fixation.

Methods to describe and measure wind erosion are well known in most countries of the OSS zone. The ROSELT/OSS observatories may need to implement joint monitoring and evaluation programmes in order to produce compatible, standard and transferable data.

Management and wetlands in an arid environment

The existence of wetlands (marches, permanently flooded areas, ponds, permanent or temporary open waters) within arid lands is important in terms of the environment and development. Wetlands host ecological differentiations related to soil water gradients and they provide opportunities for animal and human concentration, leading to centripetal vegetation and soil degradation. Some of the

ROSELT/OSS observatories exhibit such situations, justifying special efforts to determine the **relations between surface water systems and surrounding lands**. The relevant thematic approaches have been described, and must be complemented by studies on the functioning and dynamics of wetlands through relevant hydrological and ecological investigations.

Peri-urban zones

Desertification is aggravated around human settlements, as it is in all situations where water is easily accessible to both sedentary and nomadic people. Such locations require a specific thematic approach, mainly geared to restoring and rehabilitating plant cover and soils, and then to providing standards for land occupation and use.

At this stage, ROSELT/OSS does not plan to deal with environmental matters related to urban or industrial system dysfunctions, such as the pollution and other harmful effects originating from these systems.

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* * *



ROSELT/OSS : a contribution to development through its products

User's needs in terms of environmental data

A major goal of ROSELT/OSS is to provide information to users, in the form of arguments, criteria and tools for decision-making. User types are many : local and national planners, environmental reserves managers, technical government agencies (water development, forestry, rural development, mining, and so on), development project initiators (international programmes, technical services, NGOs, local associations), farmers, socio-economics operators, and international agencies. **Each user type can be associated with needs for adapted and pertinent information in terms of theme and spatial or time scales.** A most important aspect that differentiates user needs is time :

- **in the short term**, the requested information relates to development project management, to the avoidance of shortages (food, water, etc.), or to harmful effects and pollutions. The spatial scales usually concern limited areas, and precise local information is needed ;
- **in the middle term**, the requested information mainly concerns land management (especially protected areas), national and local environmental planning, or land organizational policies, especially when decentralizing ;
- **in the long term** a period often necessary for meaningful understanding of the evolution of ecological systems as related to social systems the requested information relates to the natural heritage, or to prospective planning at national, sub-regional, regional or planetary level. Long-term vision is increasingly necessary when ecosystems have been weakened, as in the OSS zone because of desertification.

ROSELT/OSS will provide users with several products based on their requests: thematic and synthesis reports, raw or processed data, thematic maps, or environmental and desertification indicators.

Thematic and synthesis reports

These reports are produced when one or several users express a need at a given moment. They derive from specific studies, based on raw or processed data, but also from a knowledge of the functioning of ecological and human systems.

They can be :

- **occasional papers** to support development projects by means of either ecological and environmental studies on the project context or impact studies. The concerned zones usually have areas compatible with the coverage of one or more relevant ROSELT/OSS observatories ;
- **thematic documents** on a resource or environment type (wood resources, changes in livestock production, etc.). Such reports are often drafted for managers, analysts and planners at higher spatial levels up to the sub-region level ;
- **prospective papers** based on the analysis of a long series of measurements and observations and a knowledge of environmental functioning models, with the goal of describing long-term changes in ecosystem-types, ecological regions, and cropping and production systems.

Raw and processed data

Data are the foundation of all production of the ROSELT/OSS observatories. These data are essentially field data, most often completed by remote-sensing data. They provide basic information directly related to the observed or measured phenomena.

Their raw form is essential for scientists in charge of the qualification and interpretation of functional mechanisms in ecosystems. Other users are more interested in comparing data : changes in time or space, or comparison with critical or threshold values indicating dysfunctions or early warning situations. The series and tables of data produced by ROSELT/OSS can be used for both purposes.

ROSELT/OSS will also produce results from processed data : means and standard deviations at various space and time scales, aggregated data, factor analysis of series. Such products are obtained from transformed data to make them more understandable by users, but they are not *a priori* responses to the requests of most users (as is the case for indicators, see p. 45).

Thematic maps

Thematic maps at various scales are the most easily accessible outputs for users ; ROSELT/OSS will make them periodically available at the local scale (observatory level when the coverage is an ecological region) and at sub-regional/regional levels. Computer-assisted mapping and powerful geographical information systems (ROSELT/OSS is developing a specific African-wide GIS) will allow ROSELT/OSS to continuously diversify its outputs on request (especially when crossing several data sources for causal relationship interpretations).

The benefits of good data sets and tools does not solve for ROSELT/OSS's or any other environmental mapping exercise all the problems related to spatial scales :

- multiple use results in multiplying scales at the user level from 1:5 000 for development projects to 1:1 000 000 for analyses at national, even sub-regional and regional levels. Processing equipment and scale-effect analysis will be affected ;
- data collection scales are usually different for different fields, even when utilization is common to all : the scales depend on data homogeneity and on the data collection network design (the number of weather stations, especially for wind recording, is very often too low among ROSELT/OSS observatories), which is often constrained by poor financing. These scales are not automatically adapted to the needs of users, which can reduce data precision.

A technical goal of ROSELT/OSS is to diagnose such problems and to establish an operating chart in order remedies with the help of the concerned countries.

Environment and desertification key-parameters

Introduction

The indicators are without the most elaborate response to users' requests. Based on a precise request, an indicator is an response fashioned from statistically processed data, modelling, and even expert-systems.

Considering the importance of such outputs to manage the environment, combat desertification, and analyse sustainable development procedures, the nation of desertification indicators must be carefully defined within ROSELT/OSS, and will be considered below and p. 47-49. In addition, the contribution of **ecological indicators** (plants and soils) within ROSELT/OSS is proposed in **annex 2**.

Concept of key-parameter

Desertification indicators can be viewed as spatial environmental indicators for use in cases of desertification.

Their definitions, characteristics and goals are similar to those of environmental indicators, as presented in OCED (1991) in the report of environmental status for Canada (1991), the IARE study of regional environmental statistics for France (1993), and in the publications of the Mediterranean observatory of the environment, Blue Plan (1994).

The first investigations using desertification indicators were made mainly in Tunisia after 1991 by CEPE/CNRS as part of a UNDP programme.

The interest shown for sustainable development, and the growing public concern about threatened environments, have led countries to re-examine the means at their disposal to evaluate and monitor environmental status, and to increase their understanding of evolutions and trends. The measurement of results is more and more urgently requested, *i.e.*, the assessment of governmental efforts to apply national environmental policies and to follow up on commitments made at an international level. Environmental indicators are thus today in prominent focus because they appear to be indispensable tools for laying the groundwork for and ensuring a sustainable future.

In May 1989, participants at the **OCED Council** meeting at the ministerial level proposed the adoption of a new work programme for a more systematic and efficient integration of environmental and economy-related decisions, in order to contribute to sustainable development. The same idea was emphasized at the **Economic summit of the group of Seven**, Paris, July 1989 ; lastly, the **Houston economic summit** (July 1990) repeated the request to OCED to boost work on environmental indicators.

OCED activities try to design groups of indicators that can integrate environmental and economic decisions at both national and international levels. The same indicators can also have a useful role for public communications. In particular, such indicators must furnish information for the ongoing dialogue between countries on suitable policies, and must provide the bases needed for international cooperation and agreements. In this respect, the role of the environmental indicators is similar to that of the economic indicators in OCED countries for economic policies coordination. **The indicators, considered, within a dynamic context, can be revised in order to reflect the evolution of political perspectives or the public awareness of environmental problems.**

Indicator groups are series obtained from larger data sets which correspond to a synthetic definition and a given objective. Consequently, one all-purpose indicator set cannot be elaborated, but several environmental indicator groups can be composed for precise situations and theoretical objectives.

Meaning of environmental key-parameters

For whomever is requesting and hence using the environments indicators, these must show :

- the quality of the environment, by determining its **status** for a specific theme or field with reference to functions, space and time. The status is described for physical and natural environments. These are translated in terms of potentials, referring thus to notions of health (dysfunction, threatened species), abundance, diversity, and distribution ;
- the constraints, damages and harmful effects endured by the environment through pressures of various origins (human, physical, etc.). Knowledge of the pressures on the environment is accompanied by an appraisal of the

factors which initiate them (human impact, natural causes, and so on). The pressures are mainly evaluated in physical terms (sometimes expressed as standards), but the evolution of costs for damage to the environment is another measurement ;

- the corrective actions used to improve the status or reduce the pressures influencing the status. These actions are a result of private or government involvement. Indicators to describe them include an evaluation of the means to apply policies and the costs born by the producers, as well as the behavioral changes of people. They are expressed through preventive or corrective actions (implementation of laws and standards, intervention and management operations).

Desertification key-parameters

Desertification indicators belong to two major groups :

- **causes of desertification**, both natural (indicators of climatic changes) and man-made (indicators, quantify human pressure on the environment).
- **effects of desertification** on biological (mainly plants and animals), physical (soils, water resources) and socio-economic environments (famines, migrations, changing behaviors, and so on).

Scales and representativity of key-parameters

Spatial scales

Desertification can be analysed at different spatial scales, ranging from local (in the ecological, agricultural, administrative meaning) up to national and international levels. Some desertification indicators can only be understood at the national (or international) level. These are always indicators obtained from economic data, for instance :

- GNP *per capita* ;
- cultivated area *per capita* ;
- food production *per capita* ;
- arid and semi-arid land percentage ;
- areas and percentages of deforestation-reforestation, etc.

Other indicators can be locally analysed and must be determined over smaller space units, even when they can be aggregated at a national level. These are ecological indicators (*sensu lato*) and some of the economic indicators related, for instance to production systems, the balance between, production and consumption, or migrations.

These indicators require a precise definition of the areas in which they are meaningful, and may not be applicable at larger mapping scales.

Representativity of parameters

Local indicators are derived from data collected in test-zones which must be selected as representative of larger areas.

Therefore, the representativeness of such zones must be quite well known before data and indicators can be extrapolated. This means :

- the entire area must be divided according to types for instance, land-use types (established from remote-sensing images or from field investigations) with each type a potential component in a stratified sample. The sampling device may vary for different data, and a compromise may be made when creating an observatory (for desertification or the environment).
- data and derived desertification indicators in each test-zone must be processed and integrated using statistics in line with the sample characteristics, and also with up-dated information on climate at a global level (rainfall or evapotranspiration evolution).

At a national level, the collection of data destined for creating indicators must be based on a network of observatories that are representative in terms of ecology, climate and agriculture.

Time scales (Rapport PNUD : TUN/88/004 – juin 1991)

The duration of an indicator's significance varies with the permanence of the data used to build the indicator. Some data change over the long term (topography, river networks) and are relatively permanent ; others may change over the medium term (for instance, flora or erosion type) ; some show short-term changes over years or seasons (for instance, soil moisture or livestock management).

When monitoring desertification or biological rehabilitation of the environment, efforts must concentrate on medium-term changes (five to twenty years). Cyclical changes must be discarded because of their short-term impact such as that, for example, following " accidents " in the annual rainfall. The consequences of intra-annual changes must be minimized, in order to better evaluate the inter-annual trends or pluri-annual series. Indeed, the goal is not to understand in detail the functioning of the system (although this may be the goal in certain cases), but to monitor the indicators of dysfunction (of salt or sand encroachment, for example) or natural rehabilitation (increased density of high quality feeding plants on rangelands).

Of course, the causes for change in the indicators are also of interest, but they are not a main monitoring goal. As an example, it is the responsibility of the engineers in charge to decide whether an increased salinity is related to poor drainage or to insufficient leaching. The monitoring unit is in no way a substitute for the executive unit in a development scheme.

Some examples of desertification key-parameters

(Rapport PNUD : TUN/88/004 – juin 1991)

Among the many characteristics of the environment which vary over time, we must look for those are only slightly influenced by rainfall in a given year, or those that allow comparison between years when their observation is made at the some time each year. It is above all the characteristics of the physical-biological and human environments that present changes over the middle term, and which thus must receive priority attention. Two major indicator groups can be evoked for each of the above environments :

Parameters for the physical and biological environment (see annex 2)

- changes in land use,
- changes in plant cover or above-ground phytomass,
- changes in the number of perennial plants,
- changes in ground status,
- changes in sand mobility,
- changes in water budget and water erosion,
- changes in secondary soil salinity,
- etc.

Parameters for socio-economics

- capital costs for infrastructure,
- changes in population density,
- contribution of major production systems,
- natural resources use,
- average grazing pressure,
- agricultural added value,
- changes in income and living standards,
- agricultural investment,
- etc.

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Formation and organization of the network

Network observatories

Situation of observatories in August 1995

As a result of the labelling procedure, Oss granted labels to twenty-nine observatories.

Descriptive forms summarizing essential information on each ROSELT/Oss observatory are proposed in a separate, attached document. The list of Oss labelled observatories in each sub-region is the following :

AFRICA NORTH OF THE SAHARA

- | | |
|----------------------|---|
| EGYPT (2) : | <ul style="list-style-type: none">• El Omayed• Matruh |
| TUNISIA (3) : | <ul style="list-style-type: none">• Haddej – Bou Hedma National Park• Oued Graguer• Menzel El Habib |
| MOROCCO (3) : | <ul style="list-style-type: none">• Issougui• Oued Mird• Fezouata |
| ALGERIA (2) : | <ul style="list-style-type: none">• Steppes on the uplands of Algeria• Tassili N'Ajjer |

Note : *The integration of Algerian observatories to ROSELT/Oss depends on :*
- *an operational mobilization, and field capabilities ;*
- *a more precise definition of proposed areas in the steppes.*

SUB-SAHARAN EAST AFRICA

ETHIOPIA (2) :

- Melka Werer
- Awash Park

KENYA (4) :

A cluster (Kibwezi - Kiboko)
of for observatories :

- Kibwezi University Station
- Tsavo East Game
- South Kiboko
- North Kiboko

SUB-SAHARAN WEST AFRICA

CAPE VERDE (2) :

- Ribeira Seca
- Ribeira Principal

MALI (3) :

- Cercle de Bourem
- Niono, delta occidental
- Boucle du Baoulé

MAURITANIA (3) :

- Nouakchott
- Boutilimit
- Banc d'Arguin

SENEGAL (2) :

- Ferlo (*pro parte*)
- Thyssé Kaymor

Remark : *in Ferlo, the discussions concluded with the necessity of concentrating on three sites (Souilène, Widou Thiengoly, Linguère).*

NIGER (3) :

A cluster of two observatories including :

- Torodi - Tondikandia et Bani Zoumbou
- Keita

A spatial distribution of the observatories is shown on the accompanying map (Figure 6), where the bioclimatic zonation has been made according to annex 1 criteria.

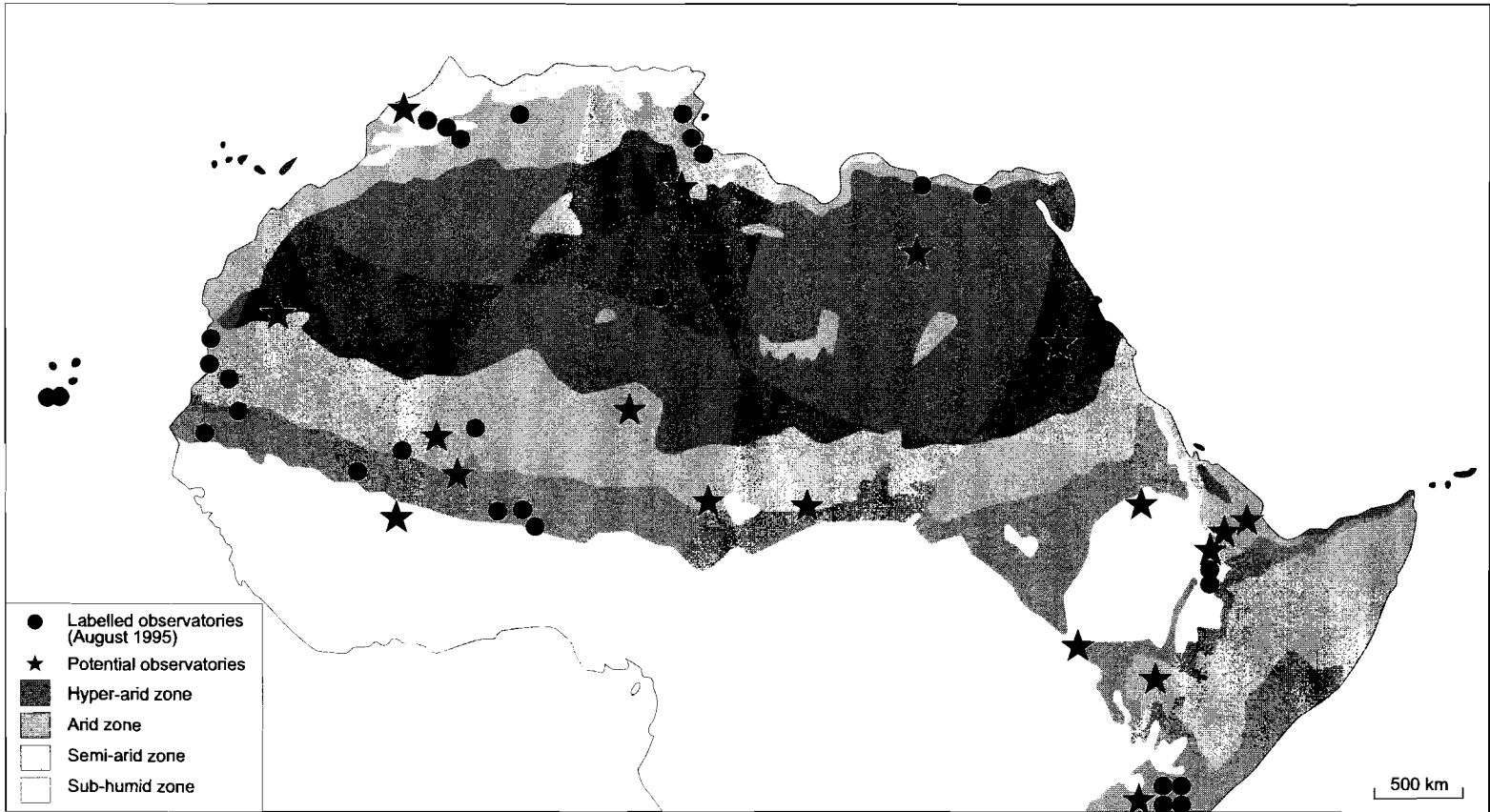


Figure 6 : Sketch-map of observatories according to aridity.

Some countries have proposed candidate territories which are acceptable for inclusion in a representative agro-bioclimatic sample ; the proposed areas should be able to meet, **under certain conditions**, the labelling criteria in the near future. Candidate territories to be considered in a second phase are :

- Burkina Faso** : Oursi Pond ; Hippo Pond.
- Egypt** : Wadi Allaqi ; one oasis.
- Ethiopia** : Gewane, Asayta.
- Kenya** : Amoboseli, cluster of Marsabit.
- Mali** : central delta of Niger.
- Morocco** : one or two sites among eight proposals (see synthesis document on observatories).
- Mauritania** : Chinguetti.
- Niger** : Air Diffa.
- Tunisia** : Jebil National Park.

In a following phase, ROSELT/OSS will invite the following countries to join the network : **Jibuti, Erythrea, Gambia, Guinea Bissau, Libya, Uganda, Sudan, Somalia, and Chad.**

Analysis of ROSELT/OSS representativity at sub-regional scale

The coherence of the ROSELT/OSS network depends on the representative character of the observatories as a whole in relation to the bioclimatic contexts and to resource uses at the sub-regional level. An overall analysis has been made for each sub-region :

- Africa north of the Sahara,
- East Africa, south of the Sahara,
- West Africa, south of the Sahara.

ROSELT/OSS representativity in Africa, north of the Sahara

Tunisia started before OSS and Morocco started at the same time as OSS working on ecological monitoring of the arid zones by proposing a relatively large number of territories that could participate in a national strategy for environmental observation along the lines set out by ROSELT/OSS.

As concerns Morocco, for instance, this could involve eleven territories that cover a rather wide range of ecosystems and agrosystems of the dry-sub-humid to the hyper-arid states, including the coastal and sub-coastal zones where the ocean or the mountains (Atlas) attenuate aridity. Morocco is the country that has the broadest range of ecological and agro-ecological systems in the Mediterranean bioclimatic zone north of the Sahara.

After meetings of OSS with its Moroccan, Tunisian, and, to a lesser extent, Egyptian partners, it was decided that countries in the arid Mediterranean bioclimate zone, in the broad sense of the term, north of the Sahara, would prioritise their proposals and submit three or four territories that fit in best with the ROSELT/OSS sub-regional and regional strategy.

Except for the TASSILI N'AJJER in Algeria and the WADI ALLAQI in Egypt which are representative of the ecogeography of the desertic climate of the central Sahara, with no, or extremely little rainfall, and no pronounced seasonal differences, and huge stretches of land bare of vegetation, all the other observatories proposed by Morocco, Algeria, Tunisia and Egypt belong to the arid and hyper-arid facies of the Mediterranean bioclimatic zone (according to Emberger's definition). Their main characteristics – which explain their basic difference with other observatories in the arid tropical bioclimates of the other two sub-regions, the ones south of the Sahara, can be described briefly as follows :

- pronounced contrasts in photoperiodism between seasons with long and with short days ;
- pronounced temperature differences between relatively cold winters and hot, dry summers ;
- annual rainfall between 250 and 50 mm (from the arid to the hyper-arid) concentrated between autumn and spring (AHEP type in the west tending towards HPEA in the east) ;
- dominant C₃ type plant species whose main growing period is between end winter and mid spring ;
- dominant steppe vegetation, scattered in the arid state and more contracted towards the hyper-arid state ;
- coexistence of pastoral systems and agriculture without irrigation (e.g. cereal aridoculture and fruit tree cropping) in the arid state, leading to systems with oasis or irrigated plots when water is available from runoff or groundwater reservoirs.

The three observatories in **Morocco** represent a gradual aridity gradient, from the arid to the hyper-arid states. In a rather limited part of the Ouarzazate Province they form a **remarkable sample of bioclimatic ecotone and population activity**, as evidenced by the recent appearance of Saharan flora from the central Sahara in plant communities dominated by Mediterranean steppe species. The three observatories together reflect most types of land use : pastoral steppe ecosystems, sparse forestland, agrosystems (rainfed or slightly irrigated grain cropping, “ oasis ” systems, etc.)

The ISSOUGUI is characterized by the presence of samples of the most southerly (thus the most vulnerable to environmental change) *Stipa tenacissima* and

Artemisia herba-alba steppes whose full diversity and most optimal characteristics are found in the observatory proposal for the steppes in Algeria (upland plains of the Oran, Algiers and Constantine regions).

The OUED MIRD, mainly covered with sparse forests of *Acacia raddiana*, has been well protected through traditional methods applied by the local populations. It is the western “counterpart” to the *A. Raddiana* found in the HADDEJ – BOU HEDMA NATIONAL PARK observatory in the arid part of Tunisia.

The collective species *A. tortilis*, which these trees from north of the Sahara are to be attached, are found in all the arid and hyper-arid zones around the Sahara. They are a very decisive bio-indicator of the biodiversity and the ecological history of this vast sub-continent.

The FEZOUATA observatory is dominated by the oasis system often found in the wadis of the piedmont of Atlas mountains in Morocco. Sand shifting is a problem because of the environmental fragility caused by the nearby sand zones.

As mentioned above, the pastoral steppe of upland north Africa, located mainly in the arid state, is well represented by the range of ecological conditions of this steppe, with **Algeria** considering a steppe observatory to reflect both North-South and West-East variability.

The **Tunisian** lowlying steppe is represented by the MENZEL HABIB, OUED GRAGUER, HADDEJ-BOU HEDMA and JEBIL observatories. Here again there is a **gradient of increasing aridity** ranging from arid to hyper-arid, with areas of pastoral steppe with *Rantherium suaveolens*, running to more open steppe of *Arthrophytum schmittianum* and contracted plant formations (*Hamada scoparia*, *Panicum turgidum*, *Calligonum comosum*, etc.). But there are also areas of rainfed grain crops on glacia and non-irrigated fruit trees plantations (olives, almonds) on deep sandy soil where agriculture may take advantage in increasing water from run-off (“jessours” system) or from water tables (oasis). To represent the two ends of the bioclimatic gradient, Tunisia is proposing two observatories working on environmental protection and conservation (the biosphere reserve BOU HEDMA NATIONAL PARK and the JEBIL NATIONAL PARK in the hyper-arid state).

Further to the east, the two **Egyptian** observatories, EL-OMAYED and MATRUH, represent highly contrasted samples of the arid part of the Western Egyptian coastal desert which, in this region, is a narrow sub-coastal strip a few dozen km. Wide on the northern fringe of the Nubian desert. There is still some scattered grain and tree cropping (olives, figs), with extremely fragile pastoral ecosystems that are often no more than residues of past agricultural systems.

Except for minor parts of the lands in the central part of the EL Omayed biosphere reserve, all the systems are subjected to the heavy human pressure.

If so designed, the ROSELT/OSS sub-regional network north of the Sahara will represent a cross-section of highly reactive ecological systems and agrosystems that will enable the network to accommodate major climatic changes in this part of the continent, e.g. increasing aridification causing the arid state to turn into a hyper-arid state in the Mediterranean bioclimatic zone which would lead to reduced distribution, of vegetation and replacement of Mediterranean steppe species by Saharan flora. This sample is extremely vulnerable if we think of the effects of human activity.

Increased human pressure could reduce potential biological production of both livestock and agriculture farmed in accordance with methods used in aridoculture (rainfed grain and tree crop farming). Indicators of sustainable development could be derived from data collected in the observatory network. Last, a biodiversity conservation strategy is applied to most observatories, especially those with the status of national parks, protected area or biosphere reserves.

In conclusion, taken globally, the measures being recommended should meet the requirements for environmental monitoring and knowledge set out in the international conventions on desertification, biodiversity and, to a lesser degree, climate change.

ROSELT/OSS representativity in East Africa, south of the Sahara

Four countries of East Africa, other than **Somalia** and **Erythrea**, have arid and semi-arid lands that fit into the ROSELT/OSS framework. Two of them (**Sudan** and **Jibouti**) expressed the intention to participate in forth coming activities but have not yet made clear proposals. Two others, **Ethiopia** and **Kenya**, both responded in a way that reflects well identified needs and the national decision in favour of effective environmental monitoring.

Ethiopia and **Kenya** both have substantial scientific teams available in a wide range of disciplines. They also have a research capacity in the candidate territories or very close to the research sites. In both cases, the intention is to involve multidisciplinary groups (30-50 members) from various organizations such as the meteorology and hydrology services, agricultural research, national parks with wildlife, rangeland management institutes, universities and their associate research groups, etc. Both countries have major cartography and remote-sensing centres, and data collection and analysis centres with specialized GIS and other sophisticated equipment.

These countries plan moderate participation in the first place of ROSELT/OSS and have clearly indicated that, for them, this phase will serve to finalize the most appropriate methods for environmental monitoring and observation. The success of

the first phase will condition the work of the national environmental control network part of which will fall under ROSELT/OSS. (Part of the network will be devoted to the wet mountainous regions). Future plans involving ROSELT/OSS apply to a rather limited area, with test zones that should generate methodology for use, by extrapolation, throughout the country.

The second characteristic of the candidate territories is that they represent a **complete gradient of lands stressed by man**, from the protected zones reserved for wildlife to the intensively formed, mechanized, irrigated agricultural lands. Between the two comes the rangelands for extensive livestock production, sedentary (or nearly sedentary) stock farming, and the (more or less) exploited woodlands. The main focus is on measuring the consequences of agricultural development activities, the corollary being monitoring natural resources and resource utilisation, maintaining the country's heritage and biodiversity, and observing socio-economic change : standard of living, land tenure and management. Assessing global climate change is still a lesser concern.

All the candidate territories have a tropical and bimodal rainfall : between 200 and 600 mm in Ethiopia, close to 600 mm in Kenya. These areas unquestionably belong to the arid and semi-arid zones, but cropping the lowlying areas is seldom possible because of the bimodal rainfall pattern, since each of the two rainy seasons is usually shorter than two months. Rainfall distribution favours certain perennials, particularly the low shrubs and the suffrutex; annual plants fare less well.

In **Kenya**, combining KIBWEZI and TSAVO EAST PARK would provide a complete range of land utilisation situations that characterize the eastern slopes of the Rift Valley : savanna with *Acacia* and *Commiphora* with a variety of wild animals (elephants, giraffes, various species of antelopes and gazelles, warthog, rhinoceros, rodents, wild animals, birds), shrubland for Kamba stock/crop farmers' cattle, sheep, and goats ; lands abandoned after unsuccessful crop farming ; relicts of forest galleries that are barely exploited because of the tsetse challenge, valley cropping with irrigation from the heavily pumped Athi river.

The KIBOKO sites, southwest of the Kibwezi and Tsavo East, is composed of rangelands controlled by the Masai who use both the hills and the vertisols with either cattle as the main stock or, when population density increases, sheep and goats. Marginal agricultural activities have been started recently using the Makindu waters; in some areas attempts are being made to reduce the shrubland.

AMBOSELI PARK, the most southerly site, is a biosphere reserve and one of the most popular tourist attractions in Kenya. It has marshlands, (some are saline) and a high concentration of wild animals (risk of overstocking when the gnus migrate). The weather is drier than in the other territories.

In **Ethiopia**, the territories combine diversity of land utilisation and a climate gradient stretching from semi-arid to arid. The rainiest area is AWASH National Park part of which is an enclosed zone grazed by a small number of antelopes and gazelles and the other part is trodden by the Kereyou cattle and wild ungulates.

MELKA WERER is a combined agricultural research station and former irrigated state farm that grows a range of crops from cotton to food crops and fruits. The site also has the relict of a riparian forest and shrubby steppe with *Acacia* and *Chrysopogon*; certain areas are protected, others are grazed by Afar dromedaries, goats and sheep.

GEWANE is a huge marshland formed by the Awash River and its tributaries, where Afar herders “take refuge” in hard times. Small areas for irrigated vegetable cropping have been created recently. There is a large variety of birds.

ASAYTA is the driest in the series of candidate territories. It includes arid ranges for dromedaries and a large irrigated area controlled by the Afars. The area is close to the end of the endoreic river, salinity has already caused some land abandonment. The area has very old productive, wild-growing date trees.

The interest of this chain of territories along the Awash Valley will be heightened when **Jibouti** has agreed to include the Jibouti aquifer in ROSELT/OSS. This aquifer/territory is located around the coast and is connected to an important city in an arid environment. The aquifer is threatened by the city's intention to expand in the direction of the boreholes.

Sudan is planning to make an observatory in the DINDER PARK; this will provide a transition between the bi- and monomodal rainfall. Sudan's potential role in ROSELT/OSS is very important. Hopefully sites will be selected at Butana (clayey plains between the Nile and Atbara) and in the Kordofan (savanna on sandy soils highly solicited, west of the Nile).

In sum, the East Africa ROSELT/OSS network offers a range of sites that are expansive enough to measure the impact of human activity and examine parameters that react to change in environmental management:

- Careful track will be kept of the availability and chemical properties of surface and ground waters.
- In rangeland systems, most species are widely spread out, but plant cover and livestock productivity will be monitored since they are reliable indicators of change.
- Careful track will be kept of the woody browse since its density is severely affected by stocking rates and human settlements.
- Changes in the size of cultivated areas (irrigated vs rainfed agriculture) are a good indicator.

Systematically observing the protected areas and monitoring changes in the sizes of relict forests and marshlands should be provided the data needed to analyse climatic change and assess damage to the biodiversity. The same is true for the lands being exploited. Comparisons should bring out the conditions for sustainable development in each type of environment.

The importance of wildlife, which is economically important in Kenya, and the behaviour of the animals which is a subtle indirect indicator of environment conservation, are also to be noted.

The design as a whole is well structured and organised, and could make a vital contribution to ROSELT/OSS. It meets the criteria for the network and reflects key concerns expressed in the international conventions on environmental protection.

ROSELT/OSS representativity in West Africa, south of the Sahara

ROSELT/OSS's main interest in West Africa is in the Sahelian biogeographic zone, the 100 to 600 mm rainfall belt, which has slid southward during the 1968 to 1990 droughts (average 110 km in Senegal, 250 km in the Tahoua province of Niger). During the last few years, however, rainfall has tended to increase.

Plant growth in the Sahel is decidedly seasonal and correlated with the highly concentrated monomodal rainfall pattern. It undergoes marked interannual variation and spatial differences. **Climatic change has been accompanied by considerable population increases** (between 2.2 and 2.8% since the 1950's).

From a short-term perspective, the soil water content is one of the key factors in Sahel vegetation growth. A low soil water rate reduces primary production of natural vegetation and harvests, which badly heightens the effects of drought. Drought alters the structure of the plant canopy and the arable soil layers causing massive reduction in wildlife and herds. The recent drought spells have led to soil water deficits that decimated browse plant communities, prevented annual plants from germinating and shrank the grass cover thus triggering serious soil erosion. Dunes that had been fixed for centuries started shifting. Decreased plant cover also tended to increase the volume and flow rate of surface runoff. Normal groundwater flows gave way to more concentrated flows which led to water erosion that favoured gully formation.

Serious herd losses during the first drought (1973) were partly due to lack of awareness by the pastoralists and agro-pastoralists who had enjoyed satisfactory rainfall levels for the score of the twenty years preceding the '70s.

From a long term perspective, decreases in primary and secondary production, reductions in perennials and in herds are trends that are quickly reversed when the

climate improves. Regeneration, however, is usually not immediate since it progresses through a series of processes and steps.

The observatories of West Africa must reflect, as best they can, the specific features of the Sahelian region which can be subdivided into three zones :

- The **Saharo-Sahelian zone**, which includes the areas bordering the mountains, is the hyper-arid and arid zone, according to ROSELT, where average annual rainfall lies between 100 and 250 mm. It is a very fragile zone because of its position as an interface with the Sahara. Vegetation ranges and soil conditions are badly affected by drought. The ultimate step in the desertification process occurs in this zone. The vegetation is mostly composed of drought-resistant trees and shrubs, e.g. *Balanites aegyptiaca*, *Acacia raddiana*, *Leptadenia pyrotechnica*, *Maerua crassifolia*, and perennial grasses, e.g. *Panicum turgidum*. The area is used for stock farming. There is no rainfed farming, only a bit of irrigated agriculture along the rivers and ponds. The extreme vulnerability of biological productivity to drought has driven people and animals southward. This zone includes all the **Mauritanian** observatories (Nouakchott and Banc d'Arguin being the most highly affected by coastal conditions) and the Bourem observatory in **Mali**. The Aïr observatory in **Niger** will round out this sample, since it includes areas along the mountains.
- The **Sahelian zone** (*sensu stricto*), characterized by average annual rainfall of between 250 and 600-600 mm, is a semi-arid zone, according to ROSELT/OSS definitions. Herding and rainfed agriculture are commonly practiced. The vegetation comprises Saharo-Sahelian species. Annuals grow in "ecological niches" in extended zones where change is very gradual. This adaptability and the topographic effects (lowlying areas) create a variety of situations and explain the wide distribution of species such as *Schoenefeldia gracilis* (a common annual grass) and woody shrubs like *Ziziphus mauritania*. The observatories representing this zone are located in Senegal (Ferlo and Thyssé-Kamor), in **Cape Verde** (Ribeira Seca and Ribeira Principal), where there is a broad gradient of altitudes and a marked coastal influence and in **Mali**, (Niono).
- The **Sahelo-Soudanian zone**, characterized by average annual rainfall of between 500 and 700 mm, is a dry sub-humid zone, according to ROSELT/OSS definitions. It is a transitional zone that is important as a zone, *per se* where the gradient reaches Soudanian conditions. It is represented by the Baoulé Park in **Mali**.

The Sahelian flora is tropical, closely connected to the Soudano-Zambesian flora of the sub-humid and humid savanna in the south. The grasses are mainly (heavily grazed) annuals. This flora is rather different from the flora found in the arid zones north of the Sahara. It is not very varied (less than 1,500 species) but the area

where this flora grows is so vast that the relative poverty in numbers is offset by a large interspecific genetic diversity. This diversity is accentuated by a gradual ecological differentiation on the fringes of the Sahel marked by changing altitudes in the mountains of southern Sahara (Adrar, Aïr, etc.) and varying soil water levels and flooding patterns in the humid zones bordering the major rivers (Niger, Senegal).

The NOUAKCHOTT observatory in **Mauritania** is characterized by recent urban pressures that have nearly destroyed the local ecosystem, before starting to replace it with peri-urban woody shrub, essentially *Prosopis juliflora* and other native species that were gradually growing extinct, such as *Balanites aegyptiaca*, *Acacia raddiana*. The temperatures and the humidity of this hyper-arid climate are very much affected by the ocean conditions.

The BANC d'ARGUIN observatory is also in the hyper-arid zone affected by ocean conditions. It is an ecotone located between a highly productive marine environment that the scientific community has studied extensively and a terrestrial component whose geomorphology and plant canopy are similar to that of the Nouakchott region. Some of the plant species found here are the same as in the North of the Sahara, e.g. *Nucularia perrini*, *Nitraria retusa*.

Still in Mauritania, the BOUTILIMIT observatory, is located in the continental hyper-arid zone and has an average annual rainfall of 125 mm. This is an important place to study as a site where sand shifting occurs in a cattle transit area during northbound transhumance; eolian erosion (deflation) is especially noteworthy. Great efforts have been made to protect the roads against sanding; this work should be continued and its environmental effects evaluated.

The BOUREM observatory in **Mali** is located in the arid zone (100 to 250 mm rainfall) where vegetation and soil deterioration are typical precursors to desertification in rangelands on this rainfall gradient near the River Niger. It is also interesting as an interface between the lifestyle of pastoral nomads and that of the sedentary farmers growing irrigated crops in the river valley. Many themes can be studied here, namely vegetation and soils, sand shifting, socio-economic issues, and land tenure.

The NIONO observatory was an enclosed ranch area where animals are now grazed and fattened near the intensively farmed ricefields of the *Office du Niger*. The zone was studied at great length to measure range yields and animal husbandry performance. The Institute of rural economics (IER) is monitoring vegetation at three sites.

The FERLO observatory in **Senegal** is composed of several ecological sites where herbaceous biomass and tree leaves are monitored regularly (some for fifteen years already). Satellite monitoring is used also. Technological facilities for exploiting data are available at CSE. This region is a good representative of a Sahelian zone faced with the problem of overexploited resources.

The THYSSE-KAYMOR observatory, located in the semi-arid Sahelian zone, is representative of an area overexploited by agriculture. Decisions related to the climate, land use, crop yields were taken some time ago. They are being implemented through hydrology and soil/water conservation programmes. There are facilities to accommodate a fulltime team of scientists.

Although the **Cape Verde** observatories at RIBEIRA SECA and RIBEIRA PRINCIPAL (Santagio Island) lie in the same climate zone as the preceding observatories, they differ by their specifically insular characteristics, *e.g.* marine environment, sharp altitude changes (and, therefore climatic niches). This puts them in a special position and justifies their inclusion.

Organization and operation of ROSELT/Oss

Integration of ROSELT/Oss observatories

Based on preliminary studies by Oss (see Preamble), the selection of observatories included in ROSELT/Oss reflects a three-tier approach :

- the first appraisal is based on a country's **ecological monitoring policies** : each country established proposals according to national policies for environment monitoring and development ;
- the second level is that of the **representativeness of the network of observatories** in relation to the agro-bio-climatic gradient found in the Oss zone A bioclimatic zoning is suggested : the sample formed by all the observatories must provide optimum representativity. Moreover, the various land cover types (at different levels of accuracy), must be present in ROSELT/Oss : from the most protected areas subject to various degrees of human impact and subject to use for grazing, crops, woodland, simple or complex models (multiple use systems) ;
- the third, is the result of the Oss **labelling ongoing procedure** of the Potential Candidate Territories (PCTS) which could become ROSELT observatories.

The procedure is based on the qualification according to several sets of criteria :

- ecological interest : bioclimatic and agroclimatic criteria ; criteria relative to vegetation and land cover ; criteria relative to soil types ; socio-economic criteria; criteria related to biodiversity ; criteria related to ecological functionality ;
- scientific and technical capacity and know-how of the PCT of interest ;
- logistics and operational capacity.

The characterization of the PCT is carried out by the member countries using a labelling form accompanied by several “ field ” forms when the PCT includes areas with different bioclimatic conditions or land uses (which is the case for most PCTs). Field missions by Oss and sub-regional experts assess the appropriateness of labelling ; **the final decision is taken by the executive secretariat of the Oss.**

Labelling procedures and criteria are detailed in document 4 of the Rabat workshop proceedings, which include labelling procedures (Doc. 4.1), labelling criteria (Doc. 4.2), PCT labelling forms (Doc. 4.3), and site forms (Doc. 4.4). These papers are available (in french) on the web site ROSELT/OSS : www.roselt-oss.org

Organization of the network

◆ *ROSELT/OSS is basically composed of observatories that have been labelled by Oss. Their number is presently (mid-1995) around thirty, but will increase in future phases as a function of requests by countries, labelling procedures and the strategy of representativeness on the part ROSELT/OSS (based on bioclimatic and land-use sampling). Some fifteen PCTs have already been analysed of inclusion in the second ROSELT/OSS phase, and conditions to be met for integration have been defined.*

The observatories collect, process and distribute basic information on their area of responsibility. They participate in the overall ROSELT/OSS approach, especially in terms of harmonising methods, improving essential knowledge of ecological monitoring, and liaising with development activities.

Coordination within ROSELT/OSS, the integration of observatories into the network, the execution of general assignments, and the elaboration of outputs are dealt with by ROSELT/OSS’s own structures, as per Oss decisions. These structures are national, sub-regional and central.

◆ *At the national level, each country in the Oss zone nominates a **ROSELT/OSS national representative**, who cooperates with a national coordinating committee made up of representatives of all agencies concerned by the network.*

The national representative’s duties are the following :

- disseminating information on ROSELT/OSS as extensively as possible throughout the country and encouraging national to include it in national environment and development plans (environmental action plans, desertification control programmes, natural resource management, information systems for environment, etc.) ;
- informing Oss and its ROSELT/OSS operator, by means of the Oss correspondents in each country or via the sub-regional levels, of the

country's evolution in terms of environmental policies, planning the progress of the observatories ;

- participating, on his country's behalf, in the preparation of documents that relate to network operations, in particular, national requests to funding bilateral or international agencies ;
- keeping track of national observatories and, in particular, participating in the characterization phase of the labelling procedure. This last point has won appropriate instructions related to the setting procedure ;
- proposing new observatories for labelling, where appropriate, as soon as the present phase has been completed ;
- organising the arrival of experts sent on behalf of ROSELT/OSS, in particular observatory expertise missions, as part of the labelling procedure, as well as expert visits to assess progress in environmental monitoring.

Fourteen countries have appointed ROSELT/OSS national representatives, as per the following list :

Burkina Faso : M. Sibiri Jean OUEDRAOGO, chef du département de recherches forestières à l'IRBET, CNRST, Ouagadougou.

Cape Verde : M. Isildo Gonçalves GOMES, *Departamento de Ciências do Ambiente*, INIDA, Praia.

Chad : M. Nandoumabe ALLARABAYE, Bureau interministériel d'études et de projets, ministère de l'agriculture et de l'environnement, N'Djamena.

Egypt : M. Mohamed ABDEL RAZIK, *Botany Department, Faculty of Science, University of Alexandria*.

Ethiopia : M. Michel CORRA, *French Veterinary and Agricultural Project*, Addis Abeba.

Jibuti : M. Mohamed A. AWALEH, Service de l'agriculture et des forêts, Jibouti.

Kenya : M. F.K. MWANGO, *Assistant Director of Water Development, Ministry of Land Reclamation, Regional and Water Development*, Nairobi.

Mali : M. Abdou Yéhia MAÏGA, programme forestier, Institut d'Économie Rurale, ministère du développement rural et de l'environnement, Bamako.

Mauritania : M. Bah Ould SID'AHMED, Division de la conservation des sols, ministère du développement rural et de l'environnement, Nouakchott.

Morocco : M. Mohamed YASSIN, Direction des eaux et forêts et de la conservation des sols, ministère de l'agriculture et de la mise en valeur agricole, Rabat.

- Niger :** M. Issoufou WATTA, directeur du projet Appui à la Gestion des Terroirs, ministère de l'hydraulique et de l'environnement, Niamey.
- Senegal :** M. Aliou DIOUF, Centre de Suivi Écologique, Dakar.
- Sudan :** M. Nadir Mohamed AWAD, *Wildlife Research Centre, Agricultural Research Corporation*, Khartoum.
- Tunisia :** M. Noureddine AKRIMI, Institut des Régions Arides, secrétariat d'état à la recherche scientifique et à la technologie, Médenine.

◆ *ROSELT/OSS's sub-regional structures* have been recognized and proposed by the various OSS structures (board of directors, scientific council, executive secretariat) and the representatives of the countries attending the Rabat workshop. The corresponding steps were taken by OSS with the relevant sub-regional agencies. CILLS from West Africa ; UMA for North Africa, which expressed a constant interest in ROSELT/OSS ; and IGAD in East Africa, which was continuously informed on ROSELT/OSS. The definition and acknowledgement of the sub-regional levels took into account the specificity of each sub-region in line with a speed of implementation based on individual context :

- in West Africa, the CILLS executive secretariat mandated the Institut du Sahel (INSAH, Bamako) as sub-regional ROSELT/OSS coordinating body in CILLS countries, a logical decision since INSAH is already in charge of sub-regional ecological monitoring. INSAH has been executing its ROSELT/OSS duties since October 1994. An active INSAH-IARE-OSS cooperation developed following the Rabat workshop (April 1994). Within INSAH, **Gaoussou TRAORÉ** is in charge of ROSELT/OSS-related activities ;
- in North and East Africa, contacts are developing between OSS, UMA and IGAD to designate the most appropriate ROSELT/OSS correspondents at sub-regional level.

Task-sharing between ROSELT/OSS's central and sub-regional structures will evolve based on the organizational capabilities of the sub-regions, which will eventually participate in all ROSELT/OSS missions. The sub-regions have an important role in coordination and the involvement of the countries, all the more so as ecological and socio-economic analyses show acute specificities in each sub-region.

◆ *At central level*, ROSELT/OSS is under the responsibility of the OSS executive secretariat and the executive director, **Chedli FEZZANI**. The OSS relies on the advice of a small orientation committee, including **Mohamed SKOURI** (UNESCO, Paris) and **Jean-Claude MENAUT** (Director of research, CNRS, École normale supérieure, Paris) and members of the OSS technical and scientific committee, namely :

- M. Antoine CORNET, Directeur du Département MAA de l'ORSTOM, Paris (France).

- M. Michel HOEPPFNER, ORSTOM-MEDIAS, Montpellier and Toulouse (France).
- M. Klaus MÜLLER-HOHENSTEIN, Universität Bayreuth (Germany).
- M. Jesse Theuri NJOKA, University of Nairobi (Kenya).

In the present operational implementation phase of ROSELT/OSS, IARE (Montpellier) has been entrusted with the responsibility of ROSELT/OSS operator. The IARE team is led by a project leader with the agreement of OSS ; this leader is presently **Alain GERBE**, a research engineer with CNRS, who is also the IARE director.

The IARE team is assisted by and under the scientific supervision of **Gilbert LONG**, honorary director or research with CNRS, former MAB-France committee president, president of the IARE scientific council.

The central ROSELT/OSS structure is responsible to OSS and is in charge of all network missions in cooperation with sub-regions and countries. Its most important role is to represent ROSELT/OSS to its partners in such tasks as harmonising the methods utilized, conceiving ROSELT/OSS outputs at a regional level, encouraging scientific and operational reflection, and defining strategies for negotiation with financial backers.

The ROSELT/OSS central body used two levels of **scientific expertise** to draw up the project and establish ROSELT/OSS :

- at the country level, OSS-appointed external experts to evaluate the PCTS on site and the environmental monitoring policies ;
- at the network level, experts were consulted, in particular to work on the labelling procedure, define the scientific and technical problems, and consider various partnerships.

As of August 1995, in addition to the already mentioned orientation committee and OSS-STC members, the following experts have also made important contributions to ROSELT/OSS :

- M. Mohamed AYYAD, professeur à l'Université d'Alexandrie (Egypt).
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Conclusion

Future steps for ROSELT/Oss

As of August 1995, the ROSELT/Oss network includes, in its first phase, some thirty Oss-labelled observatories.

As a consequence, the following major tasks are planned :

- The collection, exploitation and presentation of any necessary additional information, coming from the labelled observatories and countries, in order to develop a **ROSELT/Oss plan of action for the period 1996-99**, with the specific goal of **presenting requests** for financing to partners and backers ;
- the initiation of steps to **harmonize data collection and processing and to establish common standards** ;
- **the study of the use of satellite imagery**, so that processing tools can be worked out to **generalize Oss information** to larger geographical areas. The studies will be done in tight collaboration with all relevant ROSELT/Oss partner-agencies (...) and the Oss-SUDDAN programme ;
- the analysis in detail and definition of all **major ROSELT/Oss outputs**, in order to establish their characteristics in cooperation with concerned parties ;
- the initiation of **activities specific to each observatory**, and the organization in practice of the **sub-regional and regional cooperation** between observatories ;
- the **distribution of information** to all partners (national, sub-regional, regional, international, North-South,...).

*

* *

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ANNEXES



Annex 1

On bioclimatic zoning

This annex is essentially designed to propose a standardised, ordered system for identifying and describing MAJOR ECOLOGICAL REGIONS in the part of the Oss area concerned by ROSELT/OSS.

For this purpose a choice of variables, parameters, and climatic in being offered, based on what ecologists, agronomists and foresters feel are especially discriminative from an ecological point of view. This ecological "efficiency" is linked to the nature and mode of spatial distribution of plant communities (phytocenosis), farming and land cover systems, and, more globally, systems for natural resources of rural territories, and systems developed by the local populations for using these resources. Actually, these are also indicators that largely condition the degree of variability and intensity in relations between human activity and the natural environment.

To cope with the heterogeneity of the Oss area where the ROSELT/OSS strategy is applied, a ranking system for ordering ecological units will have to be designed; these units could be called ECOLOGICAL REGIONS or ECOREGIONS.

1st CRITERIA : first order bioclimatic zoning

The first vital, major distinction is based on the latitudinal position of the main BIOCLIMATES.

1 Mediterranean bioclimates at medium latitudes

- approximately from latitude 26° to 38°N (mainly Morocco, Algeria, Tunisia, Libya, Egypt) ;
- photoperiod and thermoperiod : strong contrasts, well defined seasons ;
- summer : always dry ;
- rains are usually concentrated in a period between Sept. and April when the days are short and the average daily temperatures are relatively low, *i.e.*, not during the hot summer season.

2 Tropical and equatorial bioclimates of the lower latitudes

- approximately from latitude 0° to 20°N (*i.e.*, all the countries in the OSS area south of the Sahara) ;
- little seasons in photoperiodism and thermoperiodism, little variations in months and seasons; rains concentrated during summer (Northern hemisphere) with rain spells between March and October, depending on the tropical or equatorial type in question ; low temperatures have little effect on plant growth except at high altitudes ($>1\ 500\text{m}$?) or because of day-night variation.

3 Desertic bioclimates

- most central regions of the Sahara, except the very high mountains; mean annual rainfall is 25 mm, frequently close to zero. Precipitation is totally unpredictable, thus making monthly or seasonal forecasts impossible.

To meet the needs of ROSELT/OSS, these first order distinctions need to be completed with more detailed information based on the values of various parameters and indicators listed here below.

Variables, parameters, climate indicators

(nearest weather station, representative of a ROSELT/OSS PCT)

- * **P** **Mean annual precipitation** expressed in mm, (if possible, P is determined using data collected for over ten years, the optimum being around thirty years).
- * **Pm** **Mean monthly precipitation** expressed in mm, (same remark as for P above).
- * **T** **Mean annual temperature** expressed in $^{\circ}\text{C}$, (if possible, T is determined using data collected during five to ten year period).
- * **Tm** **Mean monthly temperature** expressed in $^{\circ}\text{C}$, (same remark as for T above).
- * **m** **Mean minimum daytime temperature during the coldest month**, in $^{\circ}\text{C}$, (same remark as for T above).
- * **M** **Mean maximum daytime temperature during the hottest month**, in $^{\circ}\text{C}$, (same remark as for T above).
- * **ETP(p)** **Annual potential evapotranspiration**, according to the Penman equation, expressed in mm.
- * **ETP(p)m** **Monthly potential evapotranspiration**, according the Penman equation, expressed in mm.

*** P/ETP(p) Dryness index or climatic aridity index for various time increments**
(day, ten-days, month, season, year).

With **P/ETP(p) = 0.35** as the threshold value to discriminate between the “ dry periods ” and the “ rainy or potential plant growth periods ” (Le Houérou and Popov, 1981), if temperatures so allow. For Africa north of the Sahara the value of **m** has to be above +5°C; for sub-Saharan Africa, above +10°C.

Any period (day, ten days, month, season, year) during which the corresponding P(mm) is above 0.35 ETP(p)(mm) is considered as a “ rainy period favourable to plant growth ”. Conversely, any period (day, ten days, month, season, year) during which the corresponding P(mm) is below 0.35 ETP (p)(m) is considered “ a dry period, unsuited for plant growth ”.

Of course, in practice, climatic “ aridity ” can be compensated by the soil’s reserve in useable water, or aggravated by surface runoff or poor rainwater infiltration (see edaphic aridity).

*** Ombrothermic diagramme**

If the ETP(p) value cannot be easily computed, the value **P<2T** can be used as an essentially equivalent discriminating threshold to distinguish between the “ dry ” and the “ wet ” seasons, with :

P_m, mean monthly precipitation, in mm.
T_m, mean monthly temperature, in °C.

This is the figure in the ombrothermic diagramme by Bagnouls and Gausson (1953, 1957, 1964). The months of the year, from January to December are given on the X-axis, and P_m and T_m are represented on the Y-axis by the ratio P=2T.

Every month with P<2T is considered as “ dry ” and, conversely, every month with P>2T is considered as “ favourable for potential plant growth ”, with the reservation expressed above, concerning the low temperature thresholds.

*** Q₃ The simplified Emberger pluviothermic quotient**
(Stewart, 1968 ; Le Houérou, 1984)

$$\text{with } Q_3 = 3.43 \frac{P}{M} - m$$

and according to several authors (Calvet, 1966, 1971, 1979 ; Le Houérou, 1971 ; Daget, 1971 ; Le Houérou *et al.*, 1975, 1979) assuming that there is a close correlation between the variation of **M – m** and ETP.

2nd CRITERIA : second order bioclimatic zoning

Using the bioclimatic indicators listed above entails different modes of expression which can be used to envision distinctions of the second order (Le Houérou and Popov, 1981 ; Le Houérou, 1990) as shown in the table below. They apply in the Oss area, both to the **Mediterranean bioclimates north of the Sahara** and the **tropical and equatorial bioclimates south of the Sahara**.

Table 1

Description of the 2 nd order	Number of " dry " months vs Number of " rainy " months	Bioclimatic indicators and parameters
HYPER-ARID or PER-ARID	All the months of the year are " dry "	all the months report: $P_m < 0,35 \text{ ETP} (p)m$ or $P_m < 2T_m$ and $P/ETP < 0,05$ and $Q_3 < 10$
ARID	11 to 9 months of the year are " dry "	with $P_m < 0,35 \text{ ETP} (p)m$ or $P_m < 2T_m$ [$0,05 < P/ETP < 0,25$ and $10 < Q_3 < 40$]
	1 to 3 months of the year are " rainy "	with $P_m > 0,35 \text{ ETP} (p)m$ or $P_m > 2T_m$
SEMI-ARID	9 to 7 months of the year are " dry "	with $P_m < 0,35 \text{ ETP} (p)m$ or $P_m < 2T_m$ [$0,25 < P/ETP < 0,50$ and $40 < Q_3 < 70$]
	3 to 5 months of the year are " rainy "	with $P_m > 0,35 \text{ ETP} (p)m$ or $P_m > 2T_m$
SUB-HUMID	7 to 5 months of the year are " dry "	with $P_m < 0,35 \text{ ETP} (p)m$ or $P_m < 2T_m$ [$0,50 < P/ETP < 0,75$ and $70 < Q_3 < 120$]
	5 to 7 months of the year are " rainy "	with $P_m > 0,35 \text{ ETP} (p)m$ or $P_m > 2T_m$

3rd CRITERIA : third order bioclimatic zoning

This concerns the pattern of *monthly* and *seasonal rainfall distribution*, both for the Mediterranean bioclimates and for the tropical and equatorial bioclimates, in the four aridity levels defined in the 2nd criteria (hyper-arid, arid, semi-arid, sub-humid).

For tropical climates, the ombrothermic diagrammes, (in which P_m is related to T_m , according to the graphic representation on the Y axis, in compliance with the value $P=2T$), show that the " rainy " months follow two main distribution modes :

- * MONOMODAL distribution = one single " rainy " period (western part of Africa, south of the Sahara).

- * BIMODAL distribution = two “ rainy ” periods (eastern part of Africa, south of the Sahara).

There are exceptions that have to be studied individually, of course.

For the Mediterranean climates, it has been proposed that the seasonal distribution of rainfall be indicated, (1st seasonal maximum, 2nd maximum, 1st minimum, 2nd minimum). Example : APHE, where A = autumn, P = spring, H = winter and E = summer, means that autumn (Sept., Oct., Nov.) is the wettest season, and that summer (July, Aug, Sept) is the driest season.

4th CRITERIA : only applicable to mediterranean bioclimates

The value of **m** (mean minimum daily temperature during the coldest month, which is usually January but can also be December or February) can discriminate the THERMIC FACIES. The thresholds suggested are classical for most of the work on the North African bioclimatology (several references *in* Le Houérou, 1990).

m	>	9°C	VERY HOT facies
9	> m	> 7	HOT facies
7	> m	> 5	PLEASANT facies
5	> m	> 3	COOL facies
3	> m	> 1	COLD facies
1	> m	> -2	VERY COLD facies
-2	> m	> 5°C	EXTREMELY COLD facies

This discrimination, if necessary, will be adapted to the high altitude regions with tropical and equatorial bioclimates.

5th CRITERIA : only applicable to the coastal bioclimates of Mauritania, Morocco, Senegal and Cape Verde (?)

The hyper-arid , arid and semi-arid zones, as defined according to the criteria above, and located along the Atlantic coast of Africa, benefit from occult condensation (coastal fog, high hygrometry, etc.) which make up for the shortage of rainfall, as measured by traditional rain gauges. The result is that this gain in humidity can improve the water balance by decreasing the aridity and can thus improve plant growth. The same is undoubtedly also true for some parts of the East African coast.

The term “ COASTAL FACIES ” could appropriately be used for these types of Mediterranean (Morocco) and tropical (Mauritania, Senegal, Cape Verde) bioclimates.

Last, there is the singular situation found in certain parts of the central Sahara where there is no measurable (or measured) rainfall. The hypothesis is that rainfall is very irregular and that the annual mean, according to some thirty years of data, is under 25 mm. A bioclimatological and biogeographic typology could be devised for this area that is similar to the type recommended in the article by Le Houérou in *Sécheresse* (n° 4, 1990). At this stage of ROSELT/OSS development, it is probably not useful to go further than the first criteria for the central Sahara, *i.e.*, the desertic bioclimate description.

Table 2 : Review of bioclimatic parameters and criteria.

bioclimatic types	bioclimatic stages	rainfall pattern	thermic facies	coastal facies
MEDITERRANEAN	<ul style="list-style-type: none"> ★ HYPER-ARID ★ ARID ★ SEMI-ARID ★ SUB-HUMID (dry) 	Seasonal regime ★ 1 st max. ★ 2 nd max. ★ 1 st min. ★ 2 nd min.	7 facies depending on the value of m	★ Moroccan coast
TROPICAL (including <i>pro parte</i> "Equatorial")	<ul style="list-style-type: none"> ★ HYPER-ARID ★ ARID ★ SEMI-ARID ★ SUB-HUMID 	MONOMODAL or BIMODAL	Elevated zones: depending on the value of m	<ul style="list-style-type: none"> ★ Mauritanian coast ★ Cape Verde ★ Senegalese coast
DESERTIC	★ HYPER-ARID	Not applicable	Elevated zones: depending on the value of m	<ul style="list-style-type: none"> ★ Moroccan coast ★ Mauritanian coast

Examples of bioclimate descriptions (= MAJOR ECOREGIONS)

- * ARID MEDITERRANEAN BIOCLIMATE, APHE, HOT THERMIC FACIES.
- * SEMI-ARID TROPICAL BIOCLIMATE, BIMODAL.
- * HYPER-ARID TROPICAL BIOCLIMATE, MONOMODAL, COASTAL FACIES.
- * SEMI-ARID TROPICAL BIOCLIMATE, BIMODAL, THERMIC FACIES (?)
- * etc.

*

* *

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Annex 2

A contribution to an ecological characterization of desertification

Proposed indicators established from data to be collected by ROSELT/OSS observatories

The goal is to design a **set of descriptors and/or indicators of successive environmental stages, in order to produce a spatial and temporal characterization of desertification from ecological features.**

We propose as a first step a **simplified ecological approach**, based on criteria and parameters which can be easily observed or measured, but which still require care, some know-how, and adaptation to local situations.

The proposed method is valid for a **defined area of reasonable size** (1 000 – 100 000 ha, for instance), **and representative of a recurrent mosaic of ecosystems, cropping systems, or simply land-use units** which are easily identified in the field. The units are most often geographical units within the area under consideration, which can be recognized and determined by the socio-economic contributors, managers, and resource and land users, and which have been appropriately named from the vernacular of the local people.

The defined area is the **ROSELT/OSS integrated environmental observatory** or an associated observatory (cf. national ROSELT/OSS network). Observations and measurements will be made on such test-sites with relevant devices based on the environmental problems found within them.

1. Land cover : compulsory access

From the start of operations, establishment of a reference scheme, in the form of a **land-cover map**, is strongly advised; such a thematic map is the simplest special representation that can be used to program successive ecological monitoring actions and to facilitate under certain conditions the **extrapolation** of results derived from the processing of data collected from specific points in the area (ecological sites, cropped fields, and so on).

Various problems must be solved in order to establish a land-cover map : the diagnosis and naming of units, the selection of scales for investigation and representation, the choice of satellite or aerial remote-sensing data, etc. Only matters related to diagnosing and naming the units will be dealt with in the

following sections. Unit types are divided into two large groups, *i.e.*, units with a constant plant component (natural vegetation, vegetation modified by man, plantations, crops, etc.) to which an ecological monitoring procedure will be preferentially applied, and units without a plant component (apart from decorative plants such as parks, trees and shrubs along alleys, flower gardens, and so on) belonging to urban areas, roads, infrastructures, and the like).

Attention will only focus on the first group, which can be studied in **terms of flora** (list of natural and introduced species, cultivated species) **and vegetation structure** in order to characterize the **actual vegetation, natural or cultivated**.

These land-cover units are a synthetic expression of a combined criteria that describe plant communities and human impact (cf. ROSELT/OSS Doc. 4.2. of the Rabat workshop proceedings, April 1994). The following is a list of the conditions necessary to reach a minimum level of standardization in the data and diagnosis of land-cover units with a plant component.

1.1. Plant formations

The major traits of actual vegetation must be described at a given initial time (T_0 , to be determined), preferably when the **photosynthetically active vegetation** (green plants) reaches its peak. Observations and measurements will be made in the following order :

- 1 initial reconnaissance (on the ground or from remote sensing images) of the **homogeneity of the vegetated landscape**, and of the recurrent distribution of components within an ecological or geomorphological unit, up to the eco-region, agricultural sector/region levels ;
- 2 on each unit that can be delineated in space, **identification of dominant plant types** according to three types of dominance :
 - tall woody plants ($LH > 2$ m) are dominant : trees, including palm-trees ;
 - low woody plants ($LB < 2$ m) are dominant : shrubs, forbs ;
 - herbaceous (H), perennial or annual, are dominant.
- 3 from the above categories, **identification of vegetation strata** (LH, LB, H strata) and for each determination of **height classes** (lower and higher height of photosynthetically active material) in meters above ground and **cover percentage** (vertical projection of vegetation) in a representative area of landscape unit ;
- 4 in each strata, **determination of dominant and co-dominant species** which contribute to natural or cultivated vegetation physiognomies; this land-cover map. Plant species must be named using their scientific names, as in reference books (floras).

For a synthetic definition of plant formations, designation types can be

proposed, such as in **Figure 1**, which can be adapted if necessary (cf. modifying class limits).

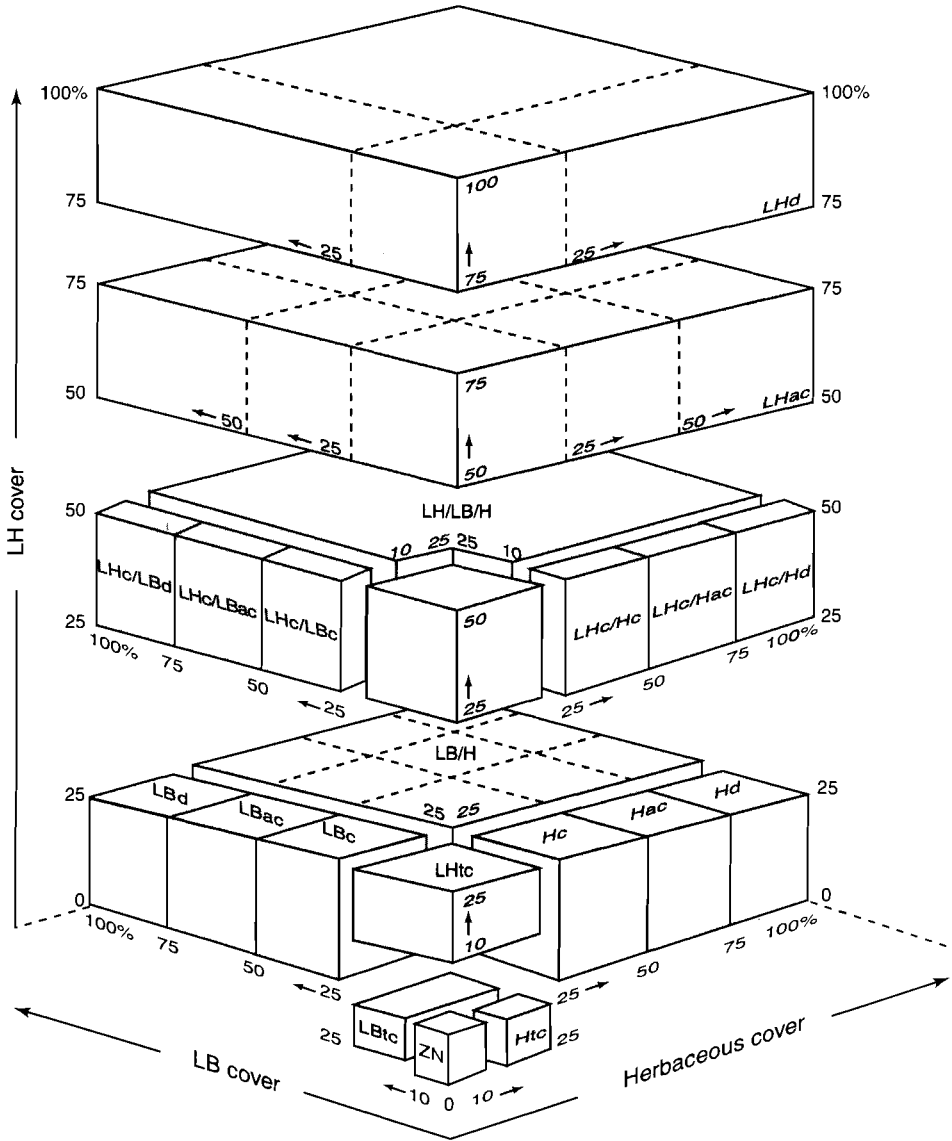


Figure 1:
 Diagram showing the major simple and complex plant formations as initially proposed by Daget (in Daget and Poissonet, 1965), and in line with the code écologique CEPE 1968, adapted for large-scale mapping of plant communities with covers over 10% (in Long 1974).

In arid zones, where plant cover is usually low, more narrowly-defined classes of cover can be adopted (for example, 0-2.5%, 2.5-5%, 5-10%, etc.). The newly adopted conventions must be maintained for future descriptions at different time intervals (two years, five years, ten years, etc.).

1.2. Artificialisation degrees and vegetation forms

In each area or observatory, human impact is estimated from a scale of seven artificialisation degrees (see ROSELT/OSS Doc. 4.2, Rabat workshop proceedings).

The combination of plant formations and artificialisation degrees characterizes what we have agreed to call **vegetation forms**.

In each area or observatory, relevant names will be attributed to **all vegetation forms** which are also land-cover units to best describe the recognized units. The pyramidal sketch in **Figure 2** is an example of requested representations.

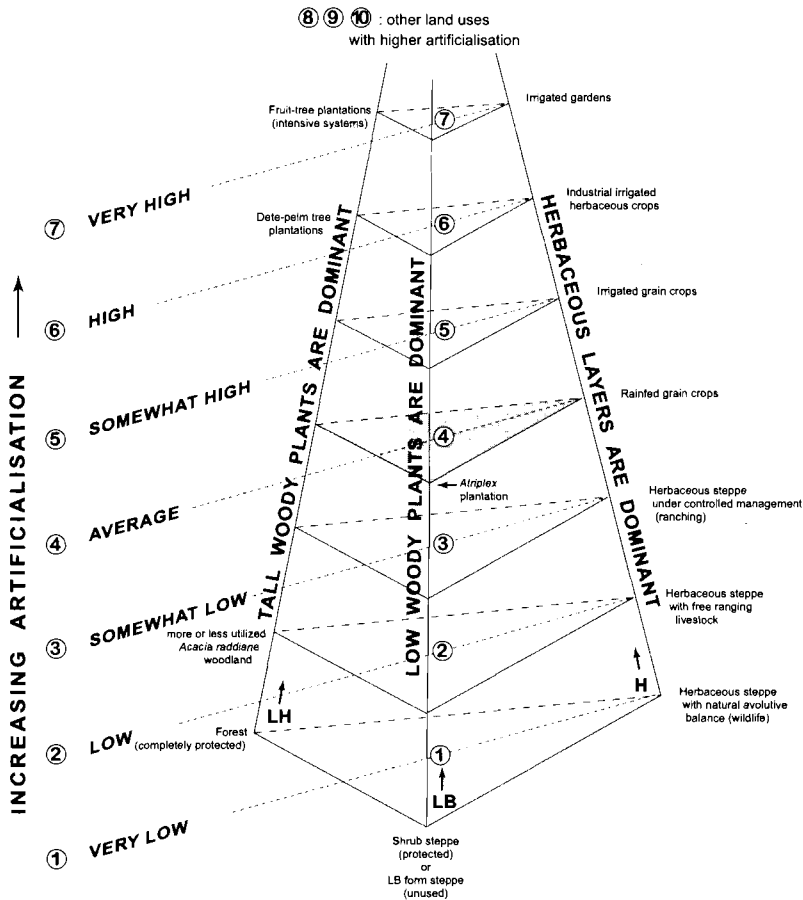


Figure 2 : Vegetation forms based on combination of plant formations and artificialisation criteria (example of North African arid lands).

Table 1 : Simple and complex plant formations for large-scale mapping.

CRITERIA AND CONVENTIONS

1. Dominant plant types and height class

Dominant tall woody plants	LH1	2 à 4 m
	LH2	4 à 8 m
	LH3	> 8 m
Dominant low woody plants	LB1	0 à 0,50 m
	LB2	0,50 à 1 m
	LB3	1 à 2 m
Dominant herbaceous	H1	0 à 0,50 m
	H2	0,50 à 1 m
	H3	> 1 m

(ZN means bare ground, or areas with less than 10 % plant cover in each of the types : LH, LB, H).

2. Cover

Total cover is expressed as a percentage for each dominant plant type in each simple or complex plant formation. Cover can be translated into vegetation " density levels " at different heights :

dense	d	75 à 100%
scattered	ac	50 à 75%
sparse	c	25 à 50%
very sparse *	tc	0 à 25%

* This class can be divided into sub-levels (0 – 2,5 ; 2,5 – 5 ; 5 – 10 ; 10 – 25 %) for plant communities with low covers.

3. Complexity

Complex plant formations are indicated by the dominant plant abbreviations separated by a slash : /

The classification of vegetation forms requires a critical analysis for each situation (observatory). Once a relevant classification has been adopted and deemed satisfactory, it must be maintained for future observations on land-cover, repeated over time at intervals selected to reflect the speed of changes in natural or artificial stress-sensitive units.

As a first approximation, periods of two, five or ten years may be considered.

Neither the techniques used to deal with satellite imagery and aerial photographs nor the techniques for establishing land-cover maps are examined here : these are widely available in national or regional remote-sensing and mapping centers of OSS zone countries.

The CORINE LAND-COVER program, designed to establish land-cover maps in Europe (cf. CORINE LAND-COVER guide), can also provide background information.

In Africa, this CORINE program is applied (cf. MEDGEOBASE program) to littoral and sub-littoral areas of Morocco and Tunisia ; FAO also runs the AFRICOVER program, which is adaptable to any country in the OSS zone where ROSELT/OSS is engaged in similar activities.

2. Phyto-ecological sampling device

Each vegetation form natural or influenced by man in the ecological surveillance area of an observatory is to be studied on **permanent sites**. The sites are areas of a few hundred square meters for the periodical sampling of **relations between vegetation and environment**, some being essential to an ecological characterization of desertification.

The number and distribution of sites must be selected according to a well **thought-out sampling scheme** (number of samples large enough to represent all diverse situations and each situation, stratified scheme according to spatial heterogeneity, etc.). Each site is studied from **permanent plots, lines or belts, or from any permanent device** which can ensure a precise relocation of samples that will be repeatedly measured at regular time intervals.

Below is a proposed **standard list of necessary observations and measurements** in order to collect data for processing within a set of descriptors and/or ecological indicators of desertification (this list is not exhaustive and may be complemented based on the specific topic in a given observatory).

1. **List of plant species : floristic composition in each vegetation layer** (Note : when establishing the first list, a curve relating the number of species to plot areas will be established ; *i.e.* area/species curve).
2. **Eye-estimate or measurement** (contact points, or line intercept along successive segments) of **plant cover** in each vegetation layer ; the contact-point method facilitates correlations with plant biomass (see below).

3. **Estimate** (indirect, see above) **or measurement** (cropping, dry-matter weighing) of **the various components of plant biomass** (standing woody phytomass, perennial or annual herbaceous phytomass, ...).
4. Determination of **density for important key-species** (trees, shrubs, etc.) : number of plants per area unit.
5. Identification of **ground components and measurement** (when possible) of **their relative cover** (or total cover within the observation permanent site). This is an evaluation at ground level (zero height) of the following elements : plants, litter, bare soil, gravels and pebbles, stones and rocks, intruding or surface solid parent rock, and organic material other than litter.
6. Determination of **soil depth** judged to be reached by plant roots and thus to contribute to soil water storing ; this indicates the soil thickness.
7. Establishment of **water profiles**, describing water contents of soil layers in substrates which characterize the sampled plant (cultivated, natural) communities.
8. Establishment of **nutrient profiles** (fertility) in soils under the various sampled plant (natural, cultivated) communities.
9. Determination of **parameters showing soil dysfunctions** (loose surface sands, salinization, water logging, etc.).

3. Main descriptors and/or indicators

The collection of data such as those listed above, systematically and repeatedly over time, enables their processing and translation into descriptors and/or ecological desertification indicators.

Data processing first results in a **description of the status of vegetation and soil at time zero**, when the initial study of the observatory-area was conducted. Repeated observations and measurements, at variable time intervals, will show changes in status, **leading to evolution** (improvements or regressions) **models**, thus providing an accurate assessment of the intensity of biological and physical environment desertification.

We list below the descriptors and/or indicators that can be tested in all ROSELT/OSS observatories for each vegetation from (or land-cover unit, or ecosystem/crop-system type).

3.1. Descriptors and/or indicators derived from land-cover (*s.str.*)

- Changes in utilized areas at variable time intervals (five years, ten years, etc.), measured from areas corresponding to different land-cover units at variable spatial definitions (5 ha, 10 ha, 50 ha, 1 sq.km, and so on) according to the characteristics of natural/man-made vegetal landscapes or ecological sectors.

- Changes over time for each land-cover unit (occupied areas, percentage of improved or damaged areas in each unit) ; elaboration and validation of a model (intermediate matrix-type).
- Proportions of various land-cover units, to show major trends in land and plant resources uses ; for example, the ratio of cultivated areas (more or less intensive crops) to rangeland livestock systems. Livestock may or may not be associated with rangeland resource controls, and with traditional-use strategies for land tenure and resources utilization.
- Indicators of change, at a comprehensive level, in artificialisation over a given area.

3.2. Descriptors and/or indicators derived from floristic composition of plant communities

- Changes in species richness indices (number of species per unit area).
- Changes in floristic diversity indices (several indices can be proposed, of which one would relate to “ red list ” species).
- Ratios of the number of species indicating stability or resilience to the number of species indicating degradation ; the numbers can, if necessary, be weighted by cover values for both groups of species.

3.3. Descriptors and/or indicators derived from vegetation structure

- Changes in canopy cover of tall woody plants (LH) per unit area and per land-cover (or plant community) unit.
- Changes in cover of low woody plants (LB) per unit area and per land-cover (or plant community) unit.
- Changes in standing phytomass (dry woody material, above ground) for trees (LH) and shrubs or forbs (LB) per unit area and per land-cover (or plant community) unit.
- Changes in herbaceous cover (H) per unit area and per land-cover (or plant community) unit. Whenever possible, perennial and annual herbaceous species must be distinguished ; covers must be measured at peak standing green phytomass.
- Changes in plant biomass (dry matter) of herbaceous species at its maximum value. If applicable, changes in pastoral values (PV) of rangelands (according to range types).
- Changes in crop yields.

NB : All the above criteria and parameters must be assessed in **relation to the consequences of various management practices and systems** on natural and human-influenced vegetation.

3.4. Descriptors and/or indicators derived from ground characteristics (per unit area, for each reference ecological system)

- Changes in litter and plant cover (ground level).
- Changes in cover of various mineral components :
 - fine texture soil (under 2 mm in diameter), with or without sealing ;
 - gravel, pebbles (from 2 mm to 2 cm) ;
 - stones, boulders (over 2 cm) ;
 - surface crusts (limestone, gypsum, etc.), iron pans ;
 - surface parent material.
- Changes in loose, mobile surface components :
 - percentage of area influenced by wind deflation ;
 - percentage of area with aeolian sand deposits ;
 - evolution of various types of deposits (veil, nebkas, barkans, heavy dunes, etc.) ;
 - etc.

3.5. Descriptors and/or indicators derived from soil water

- Changes in the depth of soil that can store water.
- Changes in the amount of water available to plants.

3.6. Descriptors and/or indicators derived from soil fertility

- Changes in organic matter content of soil top layers.
- Changes in C, N, P_2O_5 , K_2O contents.
- Changes in the C/N ratio.
- Changes in cation composition (Ca^{++} , Mg^{++} , Na^+ , K^+) and in the exchange capacity.
- Changes in salinity and waterlogging indicators.

*
* * *

List of abbreviations and acronyms

ACCT	<i>Agence de Coopération Culturelle et Technique</i> (headquarters : Paris, France).
ACP	Africa-Caribea-Pacific.
AFRICAGIS	Africa-Geographic Information System (OSS + UNITAR + UNSO).
AIOSS	<i>Association Internationale Observatoire du Sahara et du Sahel</i> (Paris, France).
CEPE	<i>Centre d'Études Phytosociologiques et Écologiques du CNRS</i> (now : CEFE, <i>Centre d'Écologie Fonctionnelle et Évolutive</i> , Montpellier, France).
CIHEAM	<i>Centre International des Hautes Études en Agronomie Méditerranéenne</i> – Centre of higher agronomy studies in the mediterranean areas (Paris, France).
CILSS	<i>Comité Inter-États de Lutte contre la Sécheresse au Sahel</i> – Permanent interstate committee for drought control in the Sahel (Ouagadougou, Burkina Faso).
CIRAD	<i>Centre de Coopération Internationale en Recherche Agronomique pour le Développement</i> – Centre for international cooperation on agronomic research and development (Paris and Montpellier, France).
CNRS	<i>Centre National de la Recherche Scientifique</i> (Paris, France).
CSE	<i>Centre de Suivi Écologique</i> (Dakar, Senegal).
EAWLS	East African Wild Life Society (Nairobi, Kenya).
EDF	European Development Fund.
EEC	European Economic Community (now, European Union – Brussels, Belgium).
ENRICH	European Network for Research in Global Change.
ESPACE	<i>Évaluation et Suivi de la Production Agricole en relation avec le Climat et l'Environnement</i> (Network in West Africa).
FAO	U.N. Food and Agriculture Organization (Rome, Italy).
GEF	Global Environment Fund.
GIS	Geographic Information System.

GCTE	Global Change Terrestrial Ecosystem (IGBP).
GTOS	Global Terrestrial Observing System (IGBP).
HAPEX	Hydrological Atmosphere Pilot EXperiment (HAPEX II, Niamey, Niger).
IARE	<i>Institut des Aménagements Régionaux et de l'Environnement</i> (Montpellier, France).
ICSU	International Council of Scientific Unions.
IDC	International Desertification Convention.
IEMVT	<i>Institut d'Élevage et de Médecine Vétérinaire des pays Tropicaux</i> (CIRAD) (now : CIRAD-EMVT).
IER	<i>Institut d'Économie Rurale</i> (Bamako, Mali).
IGAD	Inter-Governmental Authority for Development, <i>ex</i> IGADD : Inter-Governmental Authority on Drought and Development (Jibuti).
IGBP	International Geosphere Biosphere Programme (Icsu).
INCD	Intergovernmental Committee for a convention to Combat Desertification.
INSAH	<i>INstitut du SAHel</i> (Bamako, Mali).
IRA	<i>Institut des Régions Arides</i> (Médenine, Tunisia).
IRBET	<i>Institut de Recherches en Biologie et Écologie Tropicale</i> (Ouagadougou, Burkina Faso).
JRC-ISPRA	Joint Research Center (Ispra, Italy).
IUBS	International Union for Biological Sciences (Icsu) (Paris, France).
IUCN	International Union for Conservation of Nature and natural resources (Gland, Swiss).
LANDSAT-TM	Landsat Thematic Mapper.
LTER	Long Term Ecological Research (USA).
MAB	Man and Biosphere Programme (UNESCO, Paris, France).
MEDIAS	<i>Réseau de recherche régionale sur les changements de l'environnement global dans le bassin MEDiterranéen de l'Afrique Subtropicale</i> (Toulouse, France).
NGO	Non Governmental Organization.
NOAA	National Oceanographic and Atmospheric Administration (USA).
NAP	National Action Programme.

OCED	Organization for Cooperation and Economic Development.
ORSTOM	<i>Institut français de recherche scientifique pour le développement en coopération</i> – French scientific research institute for development through cooperation (Paris and Montpellier, France) (now : IRD, <i>Institut de Recherche pour le Développement</i>).
OSS	<i>Observatoire du Sahara et du Sahel</i> – Sahara and Sahel observatory (headquarters : Tunis, Tunisia).
PCT	Potential Candidate Territory (to ROSELT/OSS).
Rcs/Sahel	<i>(projet de) Renforcement des Capacités Scientifiques au Sahel.</i>
ROSELT	<i>Réseau d'Observatoires de Surveillance Écologique à Long Terme</i> – Long-term ecological monitoring observatories network.
SALT	<i>Les SAVanes sur le Long Terme</i> (network of West Africa – IGBP).
SIE	Système d'Information Intégré sur l'Environnement (de AFRICAGIS).
SPOT	<i>Satellite Pour l'Observation de la Terre</i> – satellite for observing the Earth (Toulouse, France).
SRAP	Sub-Regional Action Programme.
START	Global change system for analysis, research and training (IGBP).
TSBF	Tropical Soil Biology and Fertility (UNESCO et IUBS, Paris, France).
UMA	<i>Union du Maghreb Arabe</i> (Rabat, Morocco).
UNCED	United Nations Conference on Environment and Development (1992, Rio-de-Janeiro, Brazil).
UNDP	United Nations Development Programme.
UNEP	United Nations Environment Programme (Nairobi, Kenya).
UNESCO	United Nations Educational, Scientific and Cultural Organization (Paris, France).
UNITAR	United Nations Institute for Training and Research (Geneva, Swiss).
UNSO	United Nations Sudano-Sahelian Office (New York, USA).
URBT	<i>Unité de recherche sur les Ressources Biologiques Terrestres</i> (Algiers, Algeria).
WCED	World Commission on Environment and Development (United Nations, New York, USA).
WMO	World Meteorological Organization (Geneva, Swiss).
WRI	World Resource Institute (Washington, USA).

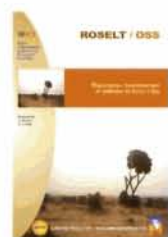
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Technical Contributions



- CT1 : Guide ROSELT/OSS pour l'évaluation et la surveillance de la végétation.
- CT2 : Guide ROSELT/OSS pour l'évaluation et le suivi des pratiques d'exploitation des ressources naturelles.
- CT3 : Manuel d'utilisation de l'outil SIEL - ROSELT/OSS (version 1.3).
- CT4 : Application des indicateurs écologiques de la dégradation des terres à l'observatoire de Menzel Habib (Tunisie).
- CT5 : Surveillance of ecological changes in the ROSELT/OSS observatory of El Omayed (Egypt) : first results.
- CT6 : Recherche des indicateurs de changement écologique et de la biodiversité dans l'observatoire de Oued Mird (Maroc) : premiers résultats.
- CT7 : Surveillance des changements écologiques dans l'observatoire ROSELT/OSS de Haddej-Bou Hedma (Tunisie) : premiers résultats.
- CT8 : Espaces-ressources-usages : première application du Système d'Information sur l'Environnement à l'échelle Locale sur l'observatoire ROSELT/OSS de Banizoumbou (Niger).
- CT9 : Recherche d'indicateurs de désertification par analyse comparative de quelques observatoires ROSELT/OSS.
- CT10 : Une approche spatiale pour la surveillance de la faune – Étude de cas au sud du Maroc : la vallée de l'oued Mird.
- CT11 : Guide pour l'évaluation et la surveillance des états de surface et des sols.
- CT12 : Système de circulation de l'information ROSELT/OSS : définition des métadonnées et élaboration des catalogues de référence.
- CT13 : Guide ROSELT/OSS pour la cartographie dynamique de la végétation et des paysages.
- CT14 : Fiches Techniques pour la construction des indicateurs écologiques ROSELT/OSS.
- CT15 : Synthèse comparative de quatre années de surveillance environnementale sur trois observatoires ROSELT/OSS du Nord de l'Afrique : El Omayed, Haddej-Bou Hedma et Oued Mird.
- CT16 : L'approche foncière environnementale : droit et anthropologie à la rencontre des sciences écologiques.

Scientific Documents



- DS1 : Conception, organisation et mise en œuvre de ROSELT/OSS.
- DS2 : Organisation, fonctionnement et méthodes de ROSELT/OSS.
- DS3 : Concepts et méthodes du SIEL - ROSELT/OSS (Système d'Information sur l'Environnement à l'échelle Locale).
- DS4 : Indicateurs écologiques ROSELT/OSS. Une première approche méthodologique pour la surveillance de la biodiversité et des changements environnementaux.
- SD1 : Conceptual, organizational and operational framework of ROSELT/OSS.
- SD2 : ROSELT/OSS organization, operation and methods, edition 2001, revised in 2004.
- SD3 : Concepts and methods of ROSELT/OSS-LEIS (Local Environment Information System).
- SD4 : ROSELT/OSS ecological indicators first methodological approach for the surveillance of biodiversity and environmental changes.



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