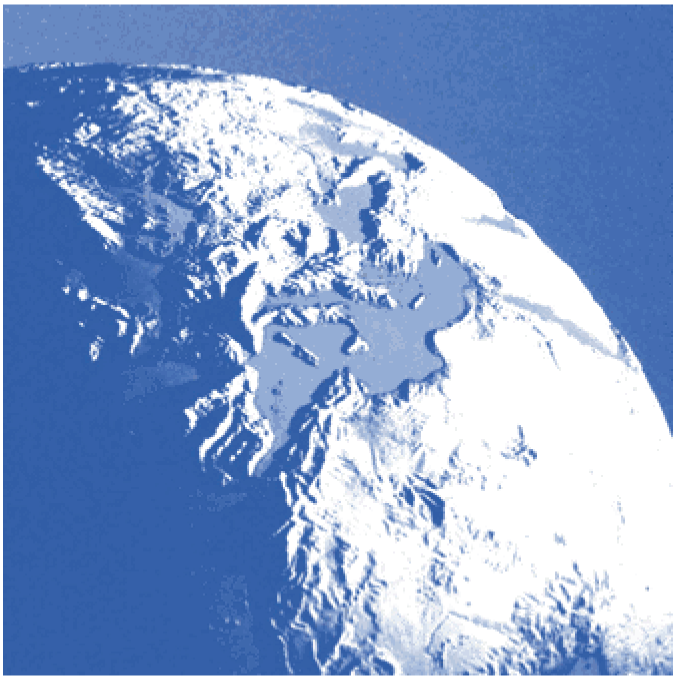
Threats to Soils in Mediterranean Countries

Document Review



Plan Bleu Papers
2

Plan Bleu
Centre d'activités régionales

Sophia Antipolis,
May 2003

This report was prepared by Laura de Franchis (Plan Bleu)
In co-operation with François Ibanez (Plan Bleu) for the cartography.
Timothy Fox translated the text from French to English.

Director of the publication: Guillaume Benoit (Director of Plan Bleu)

Acknowledgements:

Plan Bleu wishes to thank
Jean de Montgolfier and Denis Groëné
for their co-operation in reviewing this report.

Note:

Working in the framework of the Mediterranean Action Plan / UNEP, the Plan Bleu Regional Activity Center (PB/RAC) uses geographic maps following the rules applied within the United Nations. Therefore the boundaries and names shown on maps do not imply official endorsement or acceptance by either UNEP, or MAP or PB/RAC.

Plan Bleu Papers

2

Threats to Soils in Mediterranean Countries

Document Review

Plan Bleu – May, 2003

© Plan Bleu, 2003, ISBN: 2-912081-14-9

CONTENTS

LIST OF MAPS, BOXES, FIGURES AND TABLES

1. Maps

2. Boxes

3. Figures

4. Tables

LIST OF ACRONYMS AND COUNTRY CODES

1. List of acronyms

ADEME	French Agency for Environment and Energy Management
CCD	Convention to Combat Desertification
CEC	Commission for Environmental Cooperation (North American)
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies (ICAMAS)
CNEARC	French National centre for Agronomic Studies in Warm Regions (Centre national d'Etudes agronomiques des Régions chaudes)
CPCS	Commission on Pedology and Soil Cartography (Commission de Pédologie et de Cartographie des Sols)
CP-RAC	Regional Activity Centre for Cleaner Production (MAP)
CSD	Commission on Sustainable Development (UN)
DRS	Land conservation and restoration (Défense et Restauration des Sols)
EC	European Commission
EEA	European Environment Agency (European Union)
EEAA	Egyptian Environmental Affairs Agency
EEC	European Economic Community
ERS-RAC	Environment Remote Sensing Regional Activity Centre (MAP)
EU	European Union
FAO	Food and Agriculture Organization (United Nations)
GDP	Gross Domestic Product
GLASOD	Global Assessment of Soil Degradation
ICALPE	International Center for Alpine Environments
INRF	National Institute for Forestry Research (Algeria)
IRD	French Institute for research and development (former ORSTOM)
LIFE	Financial instrument of the DG-Environment (EU)
MAP	Mediterranean Action Plan
MATE	Ministry of land planning and environment (France)
MEDA	Financial and technical measures to accompany the reform of economic and social structures in the framework of the Euro-Mediterranean partnership
MEDFORUM	Mediterranean NGO network for ecology and sustainable development
MSCD	Mediterranean Commission on Sustainable Development (MAP)
NAPCD	National Action Programmes to Combat Desertification
NEAP	National Environmental Action Plan
NGO	Non Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
ONEM	Moroccan National Environment Observatory (Observatoire national de l'Environnement du Maroc)
ORSTOM	French scientific research institute for development in cooperation (now: IRD)
OSS	Sahara and Sahel Observatory
OTEDD	Tunisian Observatory for Environment and Sustainable Development (Observatoire tunisien de l'Environnement et du Développement durable)
PAP-RAC	Priority Actions Programme Regional Activity Centre (MAP)
PB-RAC	Plan Bleu Regional Activity Centre
POS	Land cover plan (Plan d'Occupation des Sols)
RAC	Regional Activity Centre (of MAP)
RAC	Regional Activity Centre (MAP)
RTM	Mountain area restoration (Restauration des terrains de montagne)
SEMC	Southern and Eastern Mediterranean Countries
SMAP	Short and Medium-Term Priority Environmental Action Programme
SPA-RAC	Specially Protected Areas Regional Activity Centre (MAP)
SWC	Soil and Water Conservation

TERRASTAT	FAO database on soils
UN	United Nations
UNCD	United Nations Conference on Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America

2. List of country codes

AL	Albania
DZ	Algeria
BA	Bosnia-Herzegovina
CY	Cyprus
WE	West Bank
HR	Croatia
EG	Egypt
ES	Spain
FR	France
GZ	Gaza Strip
GR	Greece
IL	Israel
IT	Italy
JO	Jordan
LB	Lebanon
LY	Libya
MT	Malta
MA	Morocco
MC	Monaco
PS	Palestine
PT	Portugal
SI	Slovenia
SY	Syria
TN	Tunisia
TR	Turkey
YU	Serbia and Montenegro

PREFACE

Along with water, coastlines and biodiversity, soils constitute one of the Mediterranean region's "critical" natural resources. Their enhancement and the care given to their conservation management have been a big contributor to the spread of successive civilisations. By contrast, their degradation, particularly through excessive erosion or salinisation, has in the past been a cause of sustained decline. Still today degradation in its various forms constitutes a significant threat to the future of the Mediterranean Basin.

There is a natural erosion due to the specificities of relief and pluviometry that contributes to the enrichment of the land and ecosystems located downstream. But there is a serious increase in erosion at present in numerous regions of the Basin's south and east. One important cause is the widespread rural poverty that has worsened with recent and repetitive droughts. Indeed there are still too many populations whose living conditions do not allow for sustainable investment and management (e.g. lack of land and financial security, illiteracy, a lack of basic equipments). Too dependent for their survival on poorly valued natural resources, their land is doomed to over-exploitation. This amplification is very worrying because of its environmental and socio-economic impacts (especially in arid areas threatened with desertification). Now poverty and over-exploitation may get even worse if extended to the basic farming products of the Euro-Mediterranean free-trade zone, for the lack of competitiveness of the produce from this subsistence farming would be accentuated even more.

The most fertile soils, often located downstream on plains, are threatened by large-scale urbanisation and littoralisation, induced by demographic growth, country-to-town population migration and the evolution of life-styles and production systems. The uncontrolled passage from the traditional urban core (compact town + suburban agriculture) to the motorised and tentacular city is characteristic of the entire Mediterranean space. Fertile soil sealing by urbanisation (arable land, wetlands) represents nearly irreversible degradation, significant in its scope, and would imply serious, long-term consequences if the present trends were to be confirmed.

These risks must incite a better evaluation of the situation and the stakes, possible trends and developments and conceivable "responses". As an instrument of Mediterranean co-operation in the service of all Mediterranean rim countries, Plan Bleu's task is to gather information that is useful to decision-makers and the public debate on the major Mediterranean environmental and developmental challenges. In its first general report published in 1989 ("Plan Bleu: Futures for the Mediterranean Basin"), Plan Bleu was already warning about the degradation of Mediterranean soil, considered as one of the most worrying developments in the region. Since that time, there have been few summary documents done, and we have been asked to look once again at the situation based on available documentation.

The present "Paper" reveals the difficulty of the topic. There are multiple kinds of degradations (pollution, salinisation, wind and water erosion, loss of fertility, urbanisation), and their causes are complex. The data available on the state of the soil are sporadic, not very comparable and often contradictory. Yet they do confirm the gravity of the degradation under way. The concepts put forth, such as "desertification", are the subject of controversy and questions as to the dimensions to be considered, the degree of the reversibility of the phenomena (the faculties of natural regeneration of the forest and pedogenesis should not be underestimated), the effectiveness of the systems implemented and the actions to promote. Analyses of the responses remain insufficiently documented. The bringing to light of information on real examples of good practices and the analyses of the conditions of progress, the difficulties to overcome, the costs to be considered, the instruments of action to promote, the possible margins of progress and benefits are still too scarce, not to mention the ex-post assessment of the policies implemented. Studies are all too often too theoretical, and the approaches give too much place to just the technico-scientific or sectoral aspects. It seems that action has a hard time being included in an operational way and being adapted to the diversity of situations. Yet agricultural and rural development, as well as the conservation of natural resources (water, soils, forests and biodiversity) are largely interdependent and would gain by being more globally considered within the framework of processes such as the "local agenda 21" or "biosphere reserve".

In suburban and coastal regions subjected to intense pressures, soil conservation cannot take place without new ways of thinking and acting. In the end what is being questioned is, on the one hand, the "worth" that societies attribute to resources and the price they are willing to pay for conserving their many functions; on the other, the question of "governance" for sustainable development. Now from this point of view, soil remains a "poor relation" among the natural resources that are indispensable to life and long-term development. It does not in general enjoy the attention given to water, coastlines and forests. Its ecological and productive values are not sufficiently recognised. Awareness is not on the level it should be. In contrast to water, the sustainable management of soil has not yet become a subject of debate and concern as it deserves to be.

Improving information on this subject is therefore vital. Plan Bleu will endeavour in particular over the coming years to document case studies on sustainable rural development and to strengthen its prospective thought processes. For that it will benefit of the co-operation agreements recently signed with the ICAMAS (International Centre for Advanced Mediterranean Agronomic Studies) and the FAO (the Silva Mediterranean Programme).

In conclusion I would like to congratulate Laura de Franchis, programme officer at Plan Bleu, for gathering the available information and designing and writing this document under the direction of Aline Comeau, scientific director. To carry out this task she received contributions from several experts. This document in particular owes much to Catherine Kuzukuoglü and Denis Groëné who between 1996 and 2000 carried out for Plan Bleu respectively a large compendium of information on soil in the Mediterranean region and a critical analytical note based on available information. Eric Roose, a well-known expert on Mediterranean soil, has also been generous in his advice. And last but not least Jean de Montgolfier has done the vital job of re-reading and correcting the text. Last, François Ibanez has produced the illustrations.

My particular thanks to all of them.

Guillaume BENOIT

Director, Plan Bleu

INTRODUCTION

1. Fragile Mediterranean soils, derived from a long evolution

The soils of the Mediterranean region, as we see them today, are the product of interactions that have taken place for millennia between the natural processes of pedogenesis and the activities of human societies that have developed in this region. There are scant soils that have evolved without being more or less deeply marked by direct or indirect human action. On the contrary, at one time or another in their past, much of the soils have been cleared, cultivated, planted, turned into pasture or been built on. Down through the centuries, since Neolithic times, the same place has more than likely seen various modes of occupation and uses imposed on it and at other times been abandoned and left to evolve naturally. Some soils have been profoundly reshaped through the building of terraces, dry-stone walls, levees or irrigation and drainage networks.

These human activities have sometimes been beneficial (the development of slopes into terraces, for example), but all too often they have led to more or less advanced degradation (e.g. the loss of organic matter, loss of soil structure, water and wind erosion, pollution) which have often ended up in the worst cases with the near-disappearance of the soil's unconsolidated strata.

Mediterranean soils are in general fragile, and this for several reasons, i.e. irregular and often violent precipitations promote erosion; the steepness of the slope in numerous hilly and mountainous sectors worsens this phenomenon; high temperatures accelerate the mineralisation of organic matter; the plant cover is often reduced because of the climate's severity and man-made activities and thus protect soil poorly; wind erosion is often considerable in arid or semi-arid regions; on some coastal or alluvial plains, saline watertables can lead to the salinisation of the soil.

The various occurrences of degradation, particularly erosion, are as old as the region itself and were already talked about in antiquity. Moreover in modern times new threats have appeared, which are linked to the social and economic upheavals of recent years, i.e. strong demographic growth in poor rural areas, leading to the over-exploitation of natural resources (e.g. tilling marginal areas with erosion-sensitive slopes, over-grazing, over-exploitation of fire wood); poorly done modern farming intensification in certain sectors (e.g. salinisation of the soil by poorly controlled irrigation, exaggerated use of fertilisers and pesticides); encroachment on space by urbanisation and infrastructures; urban and industrial waste pollution.

The goal of this Plan Bleu study is to provide an initial overview of the threats presently hanging over the soils of the Mediterranean countries based on a document-review approach and a critical analysis of the responses provided to counter those threats.

2. The diversity of soil types and their uses

Drawing up such an overview is a difficult task for several reasons. First because the Mediterranean soils are extremely diverse as are the ecosystems to which they belong. Altitudes vary between sea level and more than 3,000 metres. Bio-climates vary from hyper-arid (near absence of any precipitation) to hyper-humid (certain mountains receive over 2,000 mm of precipitation on average per year). And in these conditions nearly all types of soil are represented. Some are like temperate soil for which the bio-chemical weathering processes are predominant; others are more like tropical soils where the physico-chemical processes predominate. Some soils are polycyclic, i.e. they result from the succession of several phases of pedogenesis over very long periods of time; others are, by contrast, truncated, i.e. amputated by erosion of a more or less large part of their layers.

A second difficulty comes from the diversity of soil functions and uses. Soil has a two-fold nature: on the one hand it is one of the compartments of the living ecosystems to which it belongs, and on the other, it is the platform of multiple economic and social uses. It's ecological and socio-economic uses are schematised in Table 1.

Table 1: The main functions and uses of soil

Ecological functions	
Production of biomass	Soil is the platform for plant roots. It provides them with water and nutrients. It thus contributes to producing food, fodder and maintaining the quality of air and water.
Filtration, buffering capacity and self-purification	Soils physically filter insoluble substances and chemically and biologically transform and decompose mineral and organic compounds. They thus play an often very important role of self-purification and prevent harmful products from reaching watertables or the food chain.
Biological diversity and the protection of flora and fauna	Soils shelter numerous animal and plant organisms for which it is the biotope.

Socio-economical uses	
A platform for human constructions (dwellings and infrastructures)	The soil supplies the space for building dwellings, industry, roads, leisure infrastructures and the storage of waste.
A source of raw minerals and water	Soils supply several raw materials as well as combustibles (coal and oil) and underground water.
Protection and preservation of cultural heritage	The soil is an integral part of cultural and landscaped heritage. It contains paleontological and archaeological remains, which are essential for understanding the evolution of the earth and human species.

(Source: based on: EEA, 1999 [41])

A last difficulty derives from the very heterogeneous nature of the existing data on soils, despite the standardisation efforts currently underway.

3. The threats of soil degradation and the stakes in the Mediterranean region

3. 1. Definition

Talking about degradation or the threat of degradation necessarily means establishing a comparison to a reference considered more satisfactory according to a certain value scale. To be as rigorous as possible, it is always necessary to specify in relation to what reference we stand (physico-chemical, biological or ecological) and in relation to what reference uses. It would also be necessary to specify whose viewpoints and values we adopt, i.e. the soil scientist, the ecologist, the agronomist, the forester, the town planner, the geologist, the miner, the landscape architect or the palaeontologist…they do not necessarily have the same ideas as to what comprises the value of the soil, and therefore to what might threaten or degrade it.

For the remainder of this study, we will adopt the agronomist and ecologist points of view, and we will consider all forms of physical, chemical and biological changes in the soil as degradations affecting the soil's ability to ensure one or several of its functions. This could mean a quantitative loss of soil (on the surface or in depth), a decrease in its fertility or different types of pollution, i.e. salinisation, acidification, excessive use of fertilisers or pesticides, heavy metals...

Permanent or irreversible degradations can be distinguished from those that can be considered as temporary or reversible when the soil's functions can be rehabilitated in a reasonable timeframe and at an acceptable cost.

3. 2. What's at stake in soil conservation for the Mediterranean Basin

Because soil degradation affects its capacity to fulfil its ecological functions and the socio-economic uses that depend on it, soil conservation is a political and social challenge. The steps likely to be taken to respond to this challenge are highly diversified. Besides technical interventions, they can in particular include legal or regulatory changes (including changes in property and use laws), and economic actions dealing with taxes, subsidies and credit and so forth. Depending on the nature of the steps taken, redistributive effects on the various social groups will be different, and this goes for the impact on farming as well as for regional and environmental impacts.

Agricultural stakes

Agriculture has a major economic importance in most of the Mediterranean countries and goes hand in hand with a large food-processing industry both up- and downstream. It represents over 15 per cent of the GDP in numerous southern and eastern Mediterranean countries (Plan Bleu, 2001 [114]). It thus constitutes an important source of employment, especially in regions where it still remains today the major activity. Conservation of the Mediterranean agricultural potential therefore constitutes a challenge for maintaining the social and economic structure of societies. We can add that food security - even relative - is considered as a major objective by a lot of countries.

Territorial stakes

The balance of the economic activities between various regions of a country depends, among other things, on the state of its agricultural and rural economies. Soil degradation can therefore become the cause of considerable regional imbalances. The degradation of marginal lands can lead to their abandonment and to the flow of rural populations to the cities, which poses serious economic and social problems in terms of regional planning and employment. In the context of sustained demographic growth in the southern and eastern Mediterranean countries, it is necessary to maintain rural spaces capable of sustaining a large population in satisfactory economic and social conditions.

Landscaping stakes

Agriculture plays a fundamental role in the management of natural resources, space and the Mediterranean countryside (terrace crops, complex traditional water harvesting systems, water transport and use, open places linked to pastoralism, olive and chestnut groves and so forth). Abandoning certain very old developed lands (terraces, water management systems) can lead to their irreversible degradation. In such cases, soil degradation is linked to the disappearance of certain specificities of the Mediterranean environment.

Environmental stakes

Soils constitute a fundamental segment of ecosystems; their degradation therefore generally has a major impact on all other segments and seriously harms the composition and diversity of the flora and fauna as well as the water and nutrient cycles. At present, natural Mediterranean heritage is under serious threat from the disappearance of ecological land habitats (wooded areas, steppes, oases, wetlands, etc.) mainly due to clearing, desertification, pollution, the use of poor farming practices (over-exploitation, over-grazing, etc.) and the urbanisation of ecosystems. Maintaining the biological diversity of the Mediterranean environment must include the integration of ecological considerations in the planning of farming and urban development. Particular attention must be paid so that regional urbanisation does not irreversibly destroy precious ecosystems.

4. The review's contents

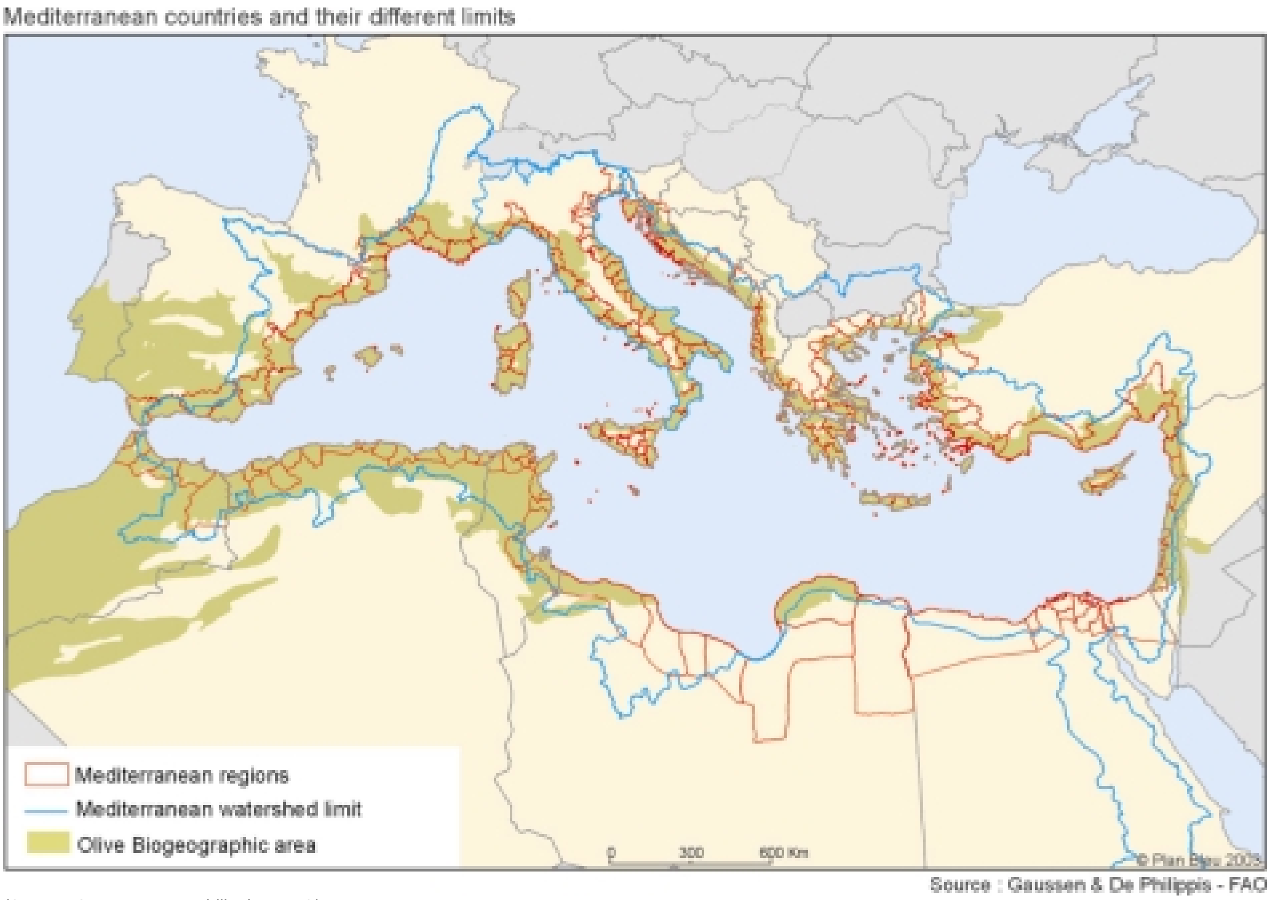
This review's first part briefly describes the context in which the Mediterranean soils are evolving, i.e. climate, geology, agroforestry and pastoral practices, urbanism... The following sections will deal successively with the main threats hanging over Mediterranean soils, i.e. land-loss through urbanisation (part 2), erosion and loss of fertility (part 3) and various kinds of pollution (part 4). In each section the phenomenon will be analysed and, insofar as possible, quantified from data gathered from documentation, keeping in mind that sources are often very heterogeneous. Then the specific existing responses for preventing or repairing the degradation will be described. The 5th section will give a quick view of the international and national policies carried out for soil conservation, analyse their insufficiencies and trace a few developmental perspectives.

PART 1: THE EVOLUTIONARY CONTEXT OF MEDITERRANEAN SOILS

Geographically speaking, the Mediterranean region stretches from the Alps to the Sahara Desert and from the Atlantic Ocean to the Caspian Sea. The 22 rim countries and territories can be divided up into 4 groups, i.e. south-western Europe (France, Italy, Monaco and Spain), south-eastern Europe (Albania, Bosnia-Herzegovina, Croatia, Greece, Malta, Montenegro, Serbia and Slovenia), the eastern Mediterranean (Cyprus, Israel, Lebanon, the Palestinian Authority, Syria and Turkey) and North Africa (Algeria, Egypt, Libya, Morocco and Tunisia).

Soil formation (pedogenesis) depends on natural factors, i.e. geology (parent rock), topography, climate and vegetation as well as man-made factors. Mankind has profoundly transformed the soils of the Mediterranean Basin for thousands of years by clearing, planting cultivating and developing terraces, levees and hydraulic structures. Nearly all Mediterranean soils therefore bear the mark of mankind. In this section we shall successively examine these two categories of factors from the angle of their relationship to the threats hanging over the soils.

Map 1: The Mediterranean countries and their Mediterranean regions



(Source: Gaussen & De Philippis – FAO)

1. Physical factors conducive to erosion

1. 1. The aggressiveness of the Mediterranean climate

The main characteristic of the Mediterranean climate is the existence of dry months in the summer[1]. In these months the potential evapotranspiration (PET) is much lower than rainfall. Moreover precipitation varies a great deal from one year to the next. The question of water supply to cultivated or natural vegetation (pastureland and woodlands) is consequently always crucial in the Mediterranean region. Rain, which mostly occurs in the cold season (over 90% of annual precipitation occurs between September and March), can be very violent and attain very strong though brief intensities (100 millimetres per hour and even more). It then causes considerable run-off, which can lead to two forms of erosion, i.e. sheet erosion and concentrated erosion in gullies, torrents or wadis.

The impact of run-off and erosion are very much aggravated when the land has been stripped (e.g. through tillage, over-grazing, recent forest fires). The other aggravating factor of erosion is the reduction in organic matter content, thus the loss of stability of the soil aggregates in the wake of inadequate farming practices. What's more, certain soils can also be rendered fragile by strong diurnal temperature variations and by the frequency on a daily scale of moistening and drying cycles, even frost and thaw, which can cause the deep cracking of clay material. In practice, the vulnerability of a soil depends a lot on its plant cover and its exposure to the sun, drying wind and showers (E. Roose, 1991 [129])

Erosion due to water run-off thus constitutes a serious threat to Mediterranean soils. As long as water flows in sheets, the transportation of solids remains limited (1 to 5 g/L). Pebble-strewn soils resist sheet-runoff detachment relatively well. It is when the water action is concentrated in gullies and wadis that the solid load becomes heavier (5 to 130 g/L) and that erosion becomes significant (E. Roose, 1991 [129]).

Wind erosion is another form that is found above all in arid and semi-arid areas where the wind tears up fine particles from the surface soil. There is a two-fold danger that threatens the soil in these areas, i.e. the first is being reduced to the skeletal state after the fine elements are removed by the wind or, on the contrary, the second is being covered over by the sand, even dunes, carried by the wind. Here too, plant cover and aggregate stability are important factors in resisting wind erosion.

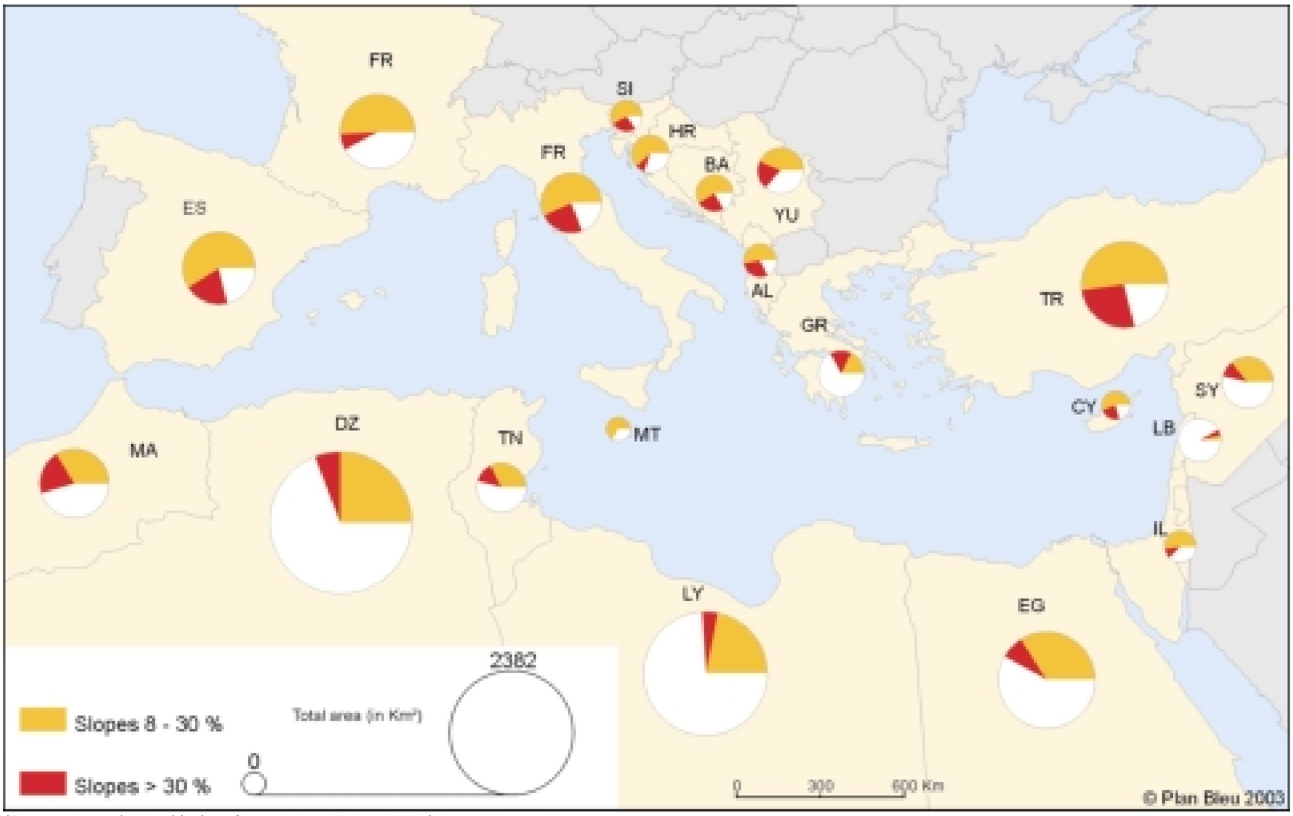
1. 2. Topography conducive to erosion

In the Mediterranean rim countries tectonics have created a very mountainous landscape. The alpine folding has caused the up-thrust of mountain chains sometimes reaching 3,000, even 4,000 metres in altitude, very folded and broken, with frequently deep valleys. Slopes are therefore often very steep. It is generally admitted that the slope is, especially in areas where the plant cover has been disturbed, one of the factors most influencing soil loss by water erosion. Exposure can also play a role; it has been observed that south-facing slopes, because of their less dense plant cover, are more vulnerable to the erosive action of water.

Even in numerous regions of medium-sized mountains whose altitudes are not very high, slopes are steep, and waterways have very tight profiles. Thus in the Tuscan Apennines (where 86% of the Arno's catchment area is not even 600 m high) slopes under 3.5 per cent cover only 15 per cent of the catchment area, whereas slopes of 10 to 20 per cent cover 35 per cent and slopes over 20 per cent cover 25 per cent of the catchment area. Analogous characteristics concerning the slope distribution are found in the Rif, the Atlas, the Taurus and the Peloponnesian mountains. According to data gathered by the FAO, of the whole region covered by the Mediterranean rim countries, 45 per cent have slopes greater than 8 per cent, and 11 per cent are over 30 per cent. Of the 20 Mediterranean rim countries, 8 (including Italy, Spain and Turkey to name just the largest) have more than 70 per cent of their land on slopes over 8 per cent.

[1] The precise definition of a dry month is, according to Gaussen, "a month in which the total precipitation in millimetres is less than double the average temperature in Celsius".

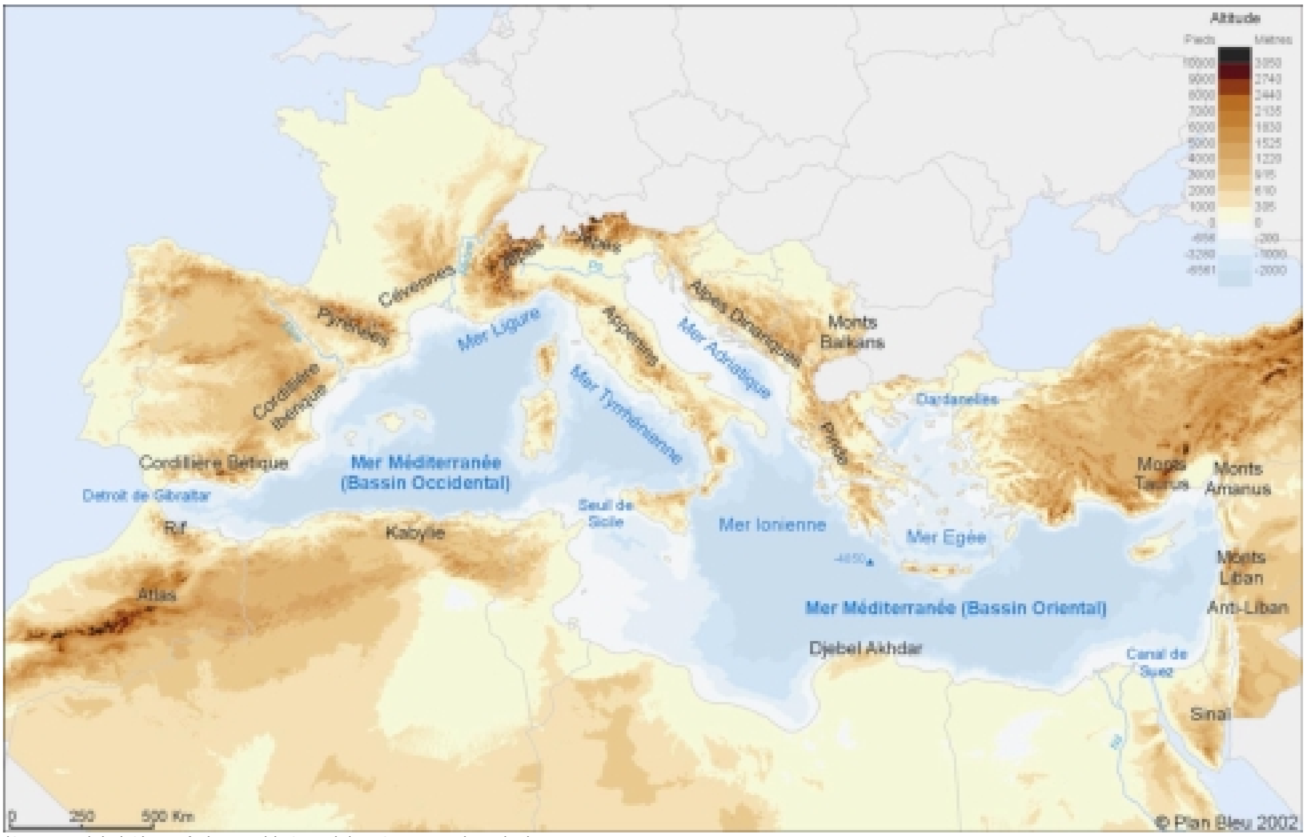
Map 2: Estimation of the distribution of soil slope classes in the Mediterranean countries



(Source: map done with data from TERRASTAT, 2001)

Tectonics explain the size of the mountains around the Mediterranean Basin. Recent, high mountains with rough-hewn shapes rise either on the sea or a few kilometres inland. The main ones can be cited: the Atlas, the Betic chain, the Pyrenees, the Alps, the Apennines, the Dinaric massif, the Pinde mountains, the Taurus and Mount Lebanon. In the northern part of the Mediterranean Basin, large plains are infrequent (the Ebre, the Rhone, the Po). On the other hand, in the southern part, of the thousands of kilometres of coastline from the Tunisian Sahel through the Nile delta to Galilee, mountains are replaced by usually flat stretches where the desert often runs to the sea.

Map 3: Overall map of the main mountainous areas of the Mediterranean



(Source: Digital Chart of The World, Copyright ESRI Inc., Plan Bleu)

2. The Mediterranean agrarian systems and their development

2. 1. The old systems

Periods of expansion and regression of human activity have alternated throughout the centuries, manifested by the expansion or regression of pressure on natural resources, especially the soil.

It is believed that the Neolithic agrarian systems relied largely on the slash-and-burn shifting cultivation technique. They probably had highly erosion effects on certain soils.

From earliest antiquity two very evolved agrarian systems developed:

- On the one hand an irrigation-based system in the alluvial plains, in particular the Nile in Egypt and the Tigris and the Euphrates in Mesopotamia. From simple flood plain tilling on the banks of flooded rivers in the high-water season, progressively they evolved towards very sophisticated hydraulic structures.
- On the other hand a dry system relying on the distribution of space in *hortus* (intensely developed and cultivated gardens), *ager* (fields cultivated with a swing plough with cereals-fallow biennial rotation), *saltus* (a more or less wooded area invested by cattle) and *silva* (relatively dense forest). One important characteristic of this system is that the cattle carried out an important transfer of fertility by grazing during the day in the *saltus* and by depositing their waste at night on the *ager* where they were parked. This transfer is probably the cause of the drop in fertility of many *saltuses*.

These systems enabled considerable development of the population and civilisation and shaped the Mediterranean agrarian landscape up to the modern period with their main characteristics being (J. de Montgolfier, 2002 [94]):

- a food base supplied by cereal-fallow biennial rotation with generally low yields;
- significant recourse to perennial plants (vines, fruit, olive and chestnut trees);
- frequent recourse to irrigation (vegetable and fruit tree crops);
- a more or less big place for cattle raising, often family oriented and integrated into the agro-sylvo-pastoral system, but in other cases nomadic or transhumant;
- more or less limited use of animal labour;
- intensive development of space: terraces, dry stone walls, earth-retaining terraces; water-catching dikes, canals, "seghias", "fogharas" and other works for transporting and gathering water needed for irrigation;
- parsimonious use of the rare natural fertilisers available, including animal waste deposited in their night time penning;
- an often fairly autarkic rural economy.

2. 2. Recent developments

Modern times have confronted these agrarian systems with the "impact of modernity", i.e. the development of transport and competition between the products of every region of the world; the development of sciences and technologies, whence the enormous progress in farming yield and the productivity of farming work made possible by fertilisers, pesticides and mechanisation; demographic transition leading at first to a very rapid growth in population; industrialisation; urbanisation; the development of tertiary activities, in particular tourism.

The various agrarian systems and the various regions bordering the Mediterranean have reacted in different ways to this impact.

The irrigated systems have in general succeeded in intensifying and spreading, which sometimes poses serious problems for the sustainable development of the soils (risks of pollution, salinisation).

The rainfed systems have on the other hand had a harder time reacting, with contrasting developments on the northern and southern sides of the Basin.

In the North, a transitory phase of over-exploitation often occurred (e.g. in 19th century Mediterranean France). It was generally followed by a - sometimes considerable - agricultural decline that provoked an abandonment of the fields of which the working had become economically marginal. Most often this desertion allowed a biological comeback that was manifested by a return to spontaneous vegetation closer to the "climax" and - in the very long term - could lead to a progressive reconstitution of the soil. But it also had disadvantages, i.e. the loss of biodiversity through landscape homogenisation; degradation of the terraces and small hydraulic works, increased risks of fire, especially when relictual cattle-raising resorted to pasture fires.

In the South, over-exploitation - which often still subsists - all too often ends up in a major degradation of the natural resources, in particular of the soil, through the extension of tillage, overgrazing and the need for fire wood as domestic fuel. Extending tilled surface areas, sometimes helped by motorization, is done to the detriment of woodland and grazing land; for example, the cultivation of the wettest pastures is progressing at an especially worrying pace in the middle Atlas (A. Conacher, 1998 [30]). With the result that the cattle are increasingly concentrated and shoved onto marginal lands, which leads to the destruction of fragile plant cover that previously more or less protected the soil from erosion. Thus in North Africa, the degradation of the plant cover has three main sources, i.e. excessive cutting of woodland, over-grazing (the "closed" dense forests are transformed into "open" forests and can even become steppes) and the extension of cultivation onto marginal lands. Because of the lack of land, even the steepest slopes can be tilled without the imperatives of soil conservation being taken into account. The surface area of cultivated lands is rapidly increasing, in particular in the piedmonts, the embankments of the mesetas plateaux and in the low hills of the mid-mountains. Grain growing has also spread in the arid zones although the latter are not very conducive to this kind of farming.

The rash extension of sporadic grain-growing has led to the degradation of a lot of arid steppe regions in North Africa and the Middle East.

3. The diversity of situations

As has already been said, the Mediterranean soils belong to very diverse types and are subject to threats that are as equally diverse. Before trying to establish a summary it is worthwhile placing this diversity.

3. 1. Various types of soil

The Mediterranean Basin is located between two very different zones from the pedogenetic point of view, i.e. in the north, where the climate is more humid, soils are generally richer in organic matter and have a relatively high humidity rate. In the south, because of extreme temperatures and their quick variation and the lack of water, there is an accelerated mineralisation of soils, which are then very sensitive to desertification. Often fragile and subject to unwise man-made activity, Mediterranean soils are often "rejuvenated" by erosion. The result is that they are then shallow, not very differentiated and poor in organic matter. They have a low water-holding capacity, which is a big handicap for the regions where there is not enough precipitation to ensure plant growth. Nonetheless there also exist in these regions deep, well structured soils that are often flat or slightly sloped with higher water holding capacity, especially in the plains. There are numerous azonal soils, the dynamics of which are ordered more by topographical than by climatic factors.

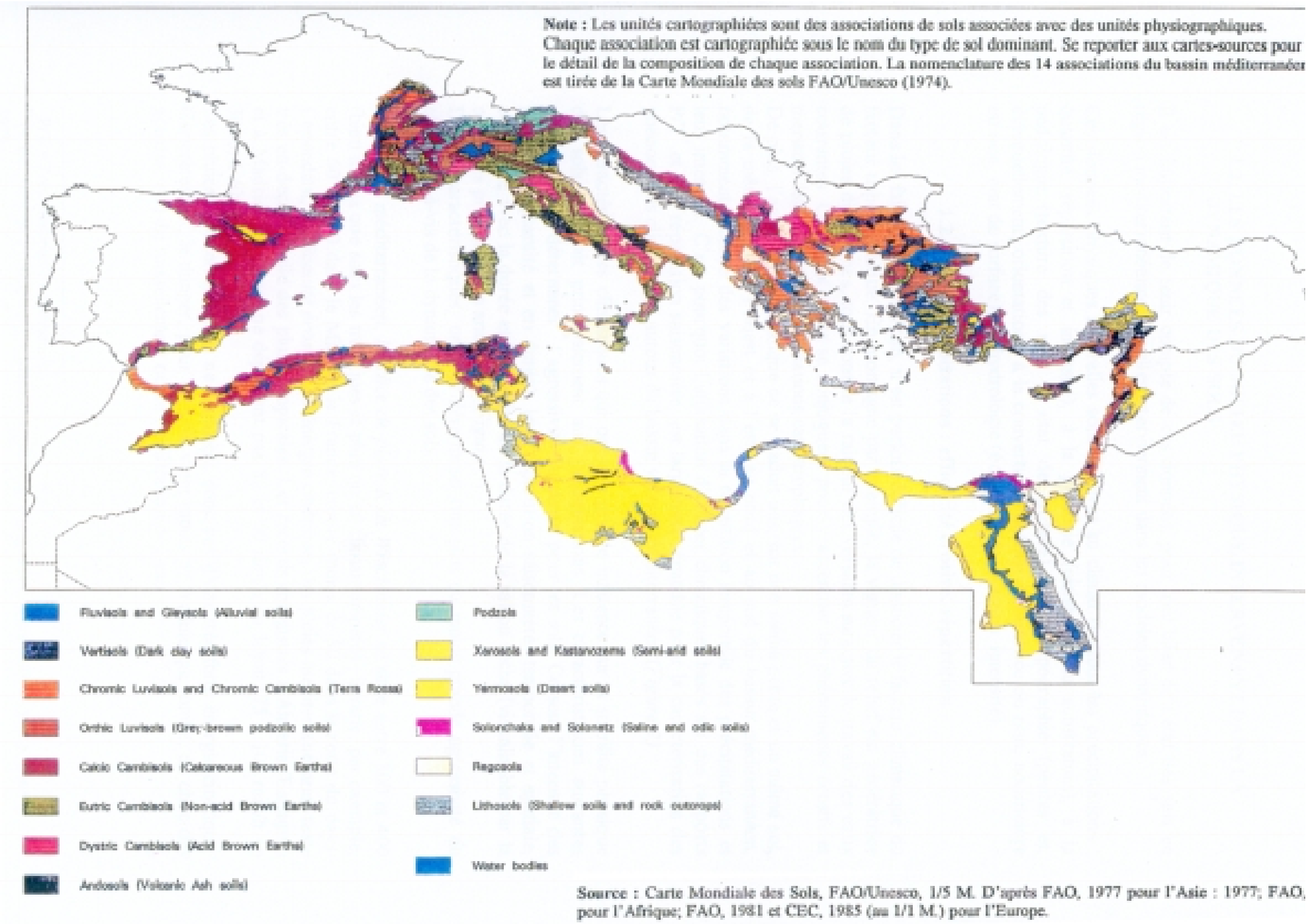
The main soil types in the Mediterranean Basin and their characteristics are summarised in Table 2. Their distribution is illustrated by Map 4. Brown soils (cambisols) are the dominant group in the Mediterranean Basin. The soils most favourable to agriculture (22% of the total) are the alluvial soils (fluvisols), the *terra rossa* soils (luvisols and chromic cambisols: 8.6%), dark clay soils (vertisols) and volcanic ash soils (andosoils).

Table 2: Description of the main Mediterranean soils

Name (different classifications)	Description
Fluvisols - FAO, 1988 Fluvents – Soil Taxonomy, 1975 Little evolved, non-climatic soils of alluvial content, - CPCS, 1967	Young alluvial soils, the region's most fertile; almost all are rich in alkaline compounds or are slightly calcareous. These soils are very important for agriculture. They appear in flat areas around main rivers such as the Ebre and the Rhone. They are adapted to a great variety of tilling and are very productive, especially when irrigated.
Regosols - FAO, 1988 Orthents - Soil Taxonomy, 1975 Little evolved, non-climatic soils of alluvial or marine content - CPCS, 1967	Young soils appearing on soft or unconsolidated terrain, often sloping; they are not very evolved or constantly rejuvenated by erosion. The topography and the water stress are their main limitations, even if some finer textured soils are fertile. When the topography is conducive, they can carry grain crops or irrigated arboriculture. In the mountain and valley regions, these soils are either extensively pastured or remain under woodland cover. They can also be found associated with sand dunes or recent soils deposited in deserts.
Leptosols - FAO, 1988 Orthens - Soil Taxonomy, 1975 Raw mineral soils CPCS, 1967	Very shallow soils, generally appearing on hard rock, sloping or very sloping terrains. Very sensitive to erosion, these soils should be left under naturally protective plant cover. When they are damaged, conservation measures should be taken. They are very present in the Mediterranean region. Woodland and extensive, controlled pasturing are the best adapted uses.
Rendzic leptosols - FAO, 1988 Xerosols - soil Taxonomy, 1975 Rendzines - CPCS, 1967	Soils always on limestone parent rock, rich in humus, often shallow with high rates of gravel; they are often present on uneven terrain. Developing intensive agriculture is possible on gently sloping land (olive trees, figs, vines, barley, vegetables, winter pasturing). On more sloping areas, woodland and controlled extensive grazing are the recommended uses.
Vertisols- FAO, 1988	Often deep and homogenous soils, characterised by high clay content. They are particularly prevalent in the Middle East and North Africa. These soils have good farming potential, but they must be the subject of specific farming practices to ensure sustainable yield. Their lack of handling ease makes them inapt for subsistence farming. Unless there are major means of mechanisation and irrigation, these soils are rather more for grazing.
Chromic luvisols - FAO, 1988 Rhodoxeralfs - Soil Taxonomy, 1975 Red Mediterranean soils, CPCS, 1967.	Generally leached soils but rich in alkaline compounds; They develop on various matter. The best-known are the terra rossa developed on hard limestone. In the mountains of Greece, Albania, Italy and Turkey, they are more of the stony type. Many are degraded because of tilling, deforestation and over-grazing.
Calcisols - FAO, 1988 Eurochrepts - Soil Taxonomy, 1975	Soils often with a significant accumulation of calcium carbonate at their base; they are in the driest of the Mediterranean climates. In North Africa they are mostly gently sloping lands used for winter grain crops and extensive cattle raising. In Spain (Andalusia) and Turkey (western Anatolia) these soils are found in valleys or mountains and are often stony. They are then mostly used for vines, grazing or woodlands.

(Source: based on CIHEAM, 1993 [26])

Map 4: The main soil types in the Mediterranean Basin



(Source: FAO in Plan Bleu, 1996 [79])

3. 2. The main threats

Artificialisation

Artificialisation designates the phenomenon of expanding built-up areas to the detriment of natural or agricultural soils. This means urbanised areas, industrial or commercial zones, communication networks, mines, landfills and building sites. It leads to the irreversible disappearance of an increasing part of the soil resource. It affects all Mediterranean areas, in particular formerly agricultural areas located on the outskirts of cities. Impact on landscapes and the organisation of space is different depending on the regions and countries, and most especially on the type of artificialisation. For example urban sprawl will have very different consequences depending on whether it is organised according to a plan or if it occurs in an uncontrolled, even illegal, fashion.

The various forms of erosion and fertility losses

In the strict sense, a soil's fertility is its chemical fertility. This means its capacity to provide plants with the nutrients that they need. In the broader sense soil fertility refers to chemical, biological and physical fertility, thus also including the soil's capacity to supply plants with solid rooting, water and oxygen. This depends on its texture, structure, composition, permeability, porosity, depth and its water holding capacity. Many of these factors themselves depend on the quality of the soil's biological life, in particular on the humification processes that are a fundamental element of soil dynamics.

Degradation is spectacular when erosion (due to water, wind or machines) goes faster than soil formation on the parent rock and when soil loses its upper layers and becomes shallower. However, other forms of degradation, less visible to the untrained eye, are very serious in terms of fertility losses. It is for example the case when the rate of organic matter decreases, leading to a loss of aggregate structure and the degradation of the soil's physical properties which can manifest itself by soil packing, the formation of a plough pan, surface crusting, reduced soil porosity and its consequent water holding capacity... This is also the case when certain chemical elements are leached and carried away (e.g. soil exhaustion in N, P, K or reduction of the cationic exchange capacity) or, on the contrary, become over abundant (salinisation, acidification, eutrophication or pollution by toxic substances).

With biological fertility being the result of a fragile balance between all the soil elements, it can be easily modified, even degraded, by physical or chemical changes in the soil.

When the biological and physicochemical properties of the soil no longer have the time to be naturally renewed, it becomes indispensable for adequate agronomic practices to enable artificial renewal (A. Ruellan, "Dégradation et gestion des sols", CNEARC, Sept. '93).

Box 1: Definition of erosion according to E. Roose

Erosion comes from the Latin verb "erodere" which means gnaw. Erosion gnaws at the earth as a dog does a bone. Whence the pessimistic interpretation of certain authors who see erosion like leprosy gnawing at the earth until nothing is left but a bleached skeleton. The limestone mountains that circle the Mediterranean are good illustrations of this process of denuding mountains when they are cleared and their meagre vegetation burned (e.g. Greece). In truth it is a natural process, which indeed deprives all mountains but in turn enriches valleys and forms rich plains that feed a good portion of humanity. It is therefore not necessarily desirable to stop all erosion but to reduce it to an acceptable, tolerable level.

(Source: E. Roose, 1994 [128])

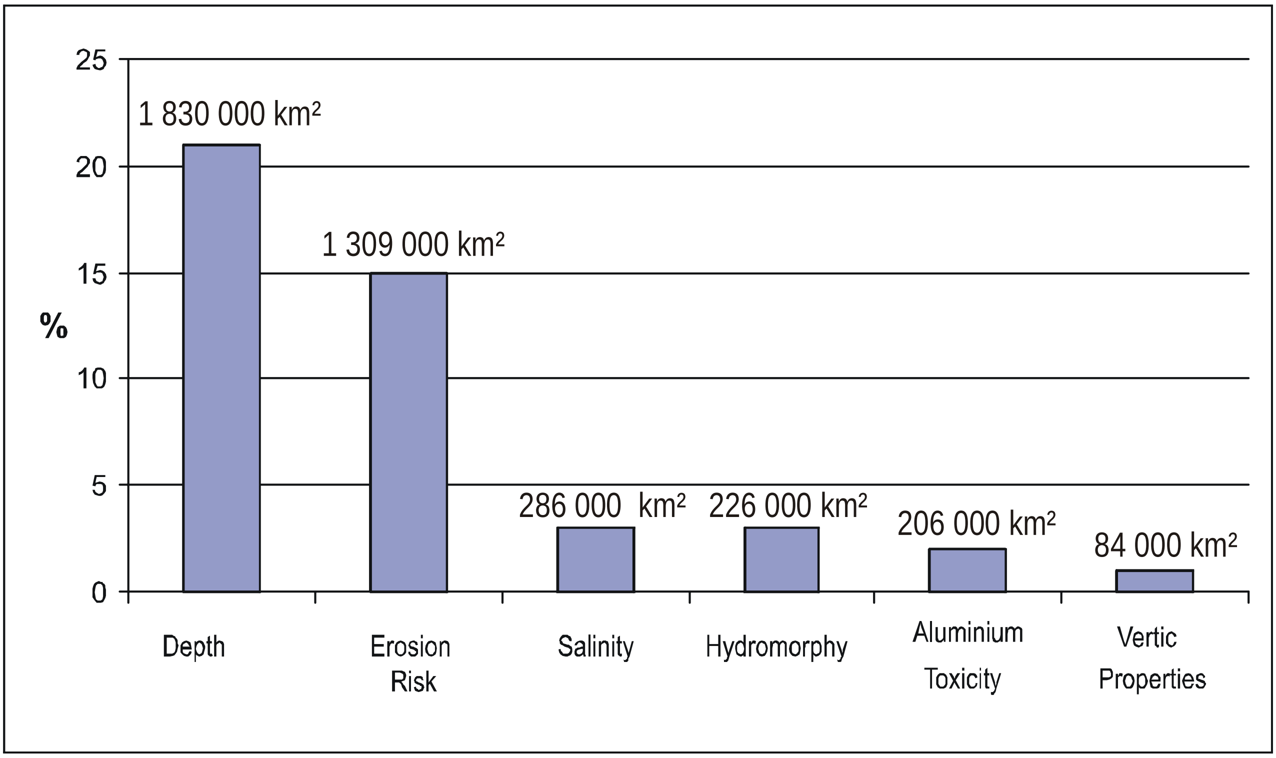
Pollutions

Here the term pollution refers to the degradation by accumulation in the soil of substances that have a harmful effect on its balance. The most obvious pollution is due to the toxic substances produced and dispersed by mankind. There is also indirect toxic pollution, which can even work in favour of plants but which can have a disturbing influence because of some elements over-concentration (the nitrates for example).

The soil's functions most affected by pollution are its filtering and self-purification capacities. If the latter are over-exploited, they no longer function properly, and the "load capacities" are exceeded. This leads to risks such as the indirect pollution of surface or ground water, pollution of the food chain through plants having grown in polluted soils and even air pollution by gaseous emissions.

These various threats are all the more serious in that a high proportion of Mediterranean cultivable soils are subject to miscellaneous limiting factors as noted in Figure 1.

Figure 1: The main limitations affecting the soils of the Mediterranean countries



(Source: based on the FAO's TERRASTAT database, 2001)

The values indicated in km² correspond to the sum of the affected national surface area. The percentage corresponds to the ratio between the affected surface area and the cumulative cultivable surface area in all countries (about 8,700,000 km²).

PART 2: SOIL LOSS THROUGH ARTIFICIALISATION

1. The main causes of artificialisation

There are mainly three pressures responsible for the increase of artificialisation the Mediterranean region:

- the development of the urban population due to country-to-city migrations, demographic growth and immigration;
- the development of new activities such as tourism, especially on the coasts, and industrialisation around urban areas and the related infrastructures that go with it;
- changes in life-style, leading to an ever more dispersed habitat.

The modalities by which these pressures are expressed are not identical in the northern, southern and eastern Mediterranean countries, but their impact on the environment is often analogous.

1. 1. Demographic pressure in the urban areas

The population of the 21 Mediterranean-rim countries has gone from 285 million in 1970 to 427 million in 2000 and could reach 524 million by 2025 according to Plan Bleu forecasts (Plan Bleu, 2001 [121]). Country-to-city migration and littoralisation are now becoming especially important in Turkey and certain other countries of the southern and eastern Basin. The extent of urban growth, especially near coasts, is explained by several things, in particular movement to cities due to the destructuring of traditional inland economies and societies; the development of economic activities near urban areas and coastlines (including certain major works of enhancing farming on coastal plains), often facilitated by important transport infrastructures; and the very rapid development of national and international tourism. These factors are cumulative with the natural demographic growth of cities.

1. 2. The development of space-consuming activities

Generally speaking, the development of tourism in both the North and South is at the origin of massive artificialisation. For example, the satellite images of the Marbella-Malaga region on the Andalusian coast of Spain, from the European "Lacoast" programme (Corine Land Cover images) show the extent and the speed of soil loss, i.e. on a 1-km wide coastal strip the capped part went from 37 per cent of the total in 1975 to 68 per cent in 1990 (i.e. an 83% growth for the period with an annual growth rate of 4%). Essentially farming lands were the main victims of this progression (from 26% to 9%, or a 64% loss), woodlands and semi-natural milieus (which regressed by 22%) and water expanses (from 1.2% of the total to 0.2%). (Plan Bleu, 2000 [120]).

Likewise with the lost-soil regions representing 35 per cent of the surface area of a 10-km wide coastal strip, the coastline of the Alpes-Maritimes in France is now the most urbanised of all French coastal regions (the average is 10% in the French Mediterranean). The urban growth of the coastline, induced by country-to-town migration and even more by the development of residential coastal tourism, is long-standing and very considerable. Certain coastal communities have seen their population multiply by 7 times in a century while population in inland areas has sometimes declined drastically. Given the coastal saturation threshold already reached, urban sprawl is now continuing inland ("middle country") at the expense mostly of farming land (the progressive disappearance of horticultural, arboricultural and market-garden businesses), i.e. on the strip from 0 to 2 km, the agricultural lands fell from 12 per cent of the surface area in 1975 to 8 per cent in 1990. On the other hand the woodlands and semi-natural areas were better protected and have resisted better, falling from 28.45 per cent in 1975 to 27.75 per cent in 1990. (Plan Bleu, 2001 [121])

In Malta it is urban sprawl and development of the tertiary sector of the economy (business services and tourism) that restrains the relative share of already reduced local natural space. Because of this, urban construction is devouring space, thus reducing the agricultural fields to narrow gardens.

Israel, studied by Sofr, Feitelson and Amiran (Y. Gradus et al., 1997, is a fine illustration (Y. Gradus et al, 1997 [65]). As in most of the developed countries the progress in farming techniques has considerably increased job productivity, greatly reducing the farming manpower needs. Faced with this situation, often indebted farmers have the choice of either leaving their farms to seek a job in town, or of converting to other business or industrial activities while staying where they are. The majority of Israeli farmers have opted for the latter solution, which has promoted the development of industrial and business activities and led to artificialisation of the soil of numerous farms. The change-over from rural areas was accented in the 90s when large-scale immigration from the countries of the former Soviet Union (nearly 660,000 arrivals between 1989 and 1995) forced the authorities to requisition land for building dwellings. In all, the immigrants' demands for housing coupled with that of inhabitants attracted to the so-called quiet of the countryside, led to the irremediable sealing of some of the nation's most fertile farming lands around the cities. The lack of a strong regulatory framework and regional planning adapted to the new situation led to more or less wildcat urbanisation and the development of often illegal and polluting activities with it all degrading the quality of resources of water, air and soil as well as the quality of life in a rural environment.

1. 3. Changes in life- and habitat styles

In all Mediterranean urban areas the urbanised surface areas progress much faster than the number of inhabitants. In the northern countries the new model consumes much more space than the dense model of European cities that existed 40 years ago. The spread of cities is no longer related to country-to-city migration or to accrued demographic pressure but to a change in life-styles. The cities of the Mediterranean North are effectively evolving towards a new model where people seek a more spacious living framework. The ease of transport provided by the omnipresent automobile makes it possible to work in town and live "in the country". This phenomenon is most important in the northern countries that have been open to the global economy more strongly and sooner. Mediterranean France, Italy, then Spain and Greece were each in turn deeply affected. Besides the fact that improved transport made living in a rural habitat more attractive to city-dwellers, the improved road networks and the job opportunities in town encouraged rural households to turn towards the urban employment market.

In **Cyprus** local urbanisation plans allocated a disproportionately large surface area to construction while the centres of towns were losing population. Essentially these plans concerned virgin lands to the detriment of already build-up areas for which renovation attempts were rare. For example since 1960 Nicosia's urban growth has occurred on the city's edges with the addition of residential districts while inside the city's limits whole stretches of urban land was left empty. Estimates reported by Nicosia's local plan show that between 1982 and 1999 the surface area given to urban development increased by 66 per cent whereas the population only grew by 38 per cent. The ratio between the growth of the urbanised surface-area and population growth was therefore of one to seven. The two main factors cited were 1) the tendency to over-value urban development needs in local planning and 2) the social pressures wielded by land owners for having their farming lands classified as constructible lands for property speculation. Despite a disproportionate potential offer of constructible land in relation to the actual demand for housing, the prices continue to rise, especially in suburban areas in anticipation of future changes in the use of land from agricultural to residential (Plan Bleu, 2001 [144]).

The southern countries have also seen their cities sprawl outwards. In the North African countries in particular (Morocco, Algeria and Tunisia) there is an observable dualism in the urban forms. On the one hand you see a broad spread of the habitat in developments organised for solvent categories of the population. On the other you see a strong concentration of the informal or spontaneous habitat of the insufficiently or irregularly solvent categories of the population. The tentacular spread of cities in the Mediterranean South goes hand in hand with a considerable transfer in the utilisation modes of the land with a loss of agricultural land, all the more precious for their being limited in quantity.

2. The extent of artificialisation

Although urban sprawl is a well-known and acknowledged phenomenon by most authors and politicians, at present there is very little reliable data about it. Data relating to the "consumption" of agricultural land by cities are already fairly limited for the European countries and are even more so for the southern and eastern countries of the Mediterranean Basin. It is therefore very hard to compare the countries, especially considering the big differences in the sources consulted.

Even in **Egypt** where this question is so vital, there is no correspondence between the figures quoted by different sources. Thus, according to a report from the Egyptian Environmental Ministry (EEAA, 1997 [44]), about 750,000 feddans of farming land were artificialised in Egypt between 1960 and 1990 (bout 315,000 ha, or about 10,000 ha per year, which means 0.29% of the 3,500,000 ha of arable land for the whole country in 1994). Since 1990 the average loss of farming land would be about 30,000 feddans per year (about 12,600 ha, which is 0.36% of the extant arable land in 1994. Now, other figures cited by Mr. Chaline (Plan Bleu, 2001 [24]) show a loss of 25,000 ha of good farming land as an annual average since 1952 (which would represent in all 1,225,000 hectares in 49 years, or 35% of the country's entire arable land) through urbanisation.

In **Lebanon**, nearly 7 per cent of all arable land in the country in 1994 and an even bigger proportion (15%) of the irrigated land have disappeared because of expanding urban areas over the past 20 years (Plan Bleu, 1999 [117]). In Tunisia the growth of Sfax since 1992 is said to have absorbed 9,000 ha of agricultural gardens. In **Algeria** the poorly controlled spread of greater Algiers is said to have devoured 140,000 ha of fertile land, particularly in the Mitija plain. In **Turkey** about 150,000 ha of good agricultural land is said to have been irreversibly lost to urbanisation between 1978 and 1998 (Plan Bleu, 2001 [24]). Up to 1910 in **Malta** only 6 per cent of the Maltese islands area was urbanised as opposed to 21 per cent now (28% if we consider only the main island). At least 6 per cent of the Maltese islands has been sealed by roads and quarries (A. Baldacchino et al., 1999 [7]). Without quoting figures, the EEA estimates that in most of the European countries the land surface lost through urbanisation exceeds that affected by erosion (EEA, 1998 [40]). In **France** artificialisation is said to constitute the main threat to the land and concerns a yearly average of 40,000 ha according to the French Institute for the Environment (IFEN, 1999[71]), or 50,000 ha according to M. Chaline (Plan Bleu 2001 [24]). In **Italy** 30,000 ha of very productive farming land is said to disappear every year (Italia, Ministero dell'Ambiente, 1997[73]). In **Greece** the loss of good farming land due to the encroachment of industrial and urban areas between 1971 and 1981 was (under) estimated at a minimum of 20,000 ha (which represents 0.57% of the whole country's arable land in 1994 (Greece, Ministries of Foreign Affairs, National Economy and Environment, Physical Planning and Public Works, 1992 [66]).

Table 3 records the figures found in available documents about the loss of land through artificialisation. Despite a certain reserve concerning the reported figures, we have decided to quote them for they make it possible to get an idea of the magnitude of the surface areas concerned.

Table 3: The artificialisation of agricultural land in various Mediterranean countries

Pays	Period	Agri. losses over period (ha)	Arable land in 1994 (ha)	Losses / arable land 1994 (%)	Annual losses / arable land 1994 (%)	Data sources
Algeria	Not specified	(1) 140,000	8,043,000	1.75		Official land management documents quoted by Chaline - Plan Bleu, 2001 (24)
Cyprus*	1985-2001*	(2) 3,200	143,000	2.24	0.14	Glafkos Constantinides in Chaline - Plan Bleu, 2001 (24)
Egypt	1960-1990	315,000	3,500,000	9.00	0.30	EEAA, 1997 (44)
Egypt*	1990-1996*	75,600	3,500,000	2.16	0.36	EEAA, 1997 (44)
Egypt*	1952-2001*	(3)		35.00	0.71	Galila El Kadi in Chaline - Plan Bleu, 2001 (24)
France	1991-1997	(4) 230,000	19,488,000	1.18	0.20	IFEN, 1999 (71)
France	Year not specified	50,000	19,488,000	0.26	0.26	Chaline - Plan Bleu, 2001 (24)
Greece	1971-1981	(5) 20,000	3,502,000	0.57	0.06	Greece, Ministries of Foreign Affairs, National Economy and Environment, Physical Planning and Public Works, 1992 (66)).
Italy	Year not specified	(6) 30,000	11,143,000	0.27	0.27	Italia, Ministero dell' Ambiente, 1999 (73)).
Lebanon	Last 20 years	20,000	306,000	6.54	0.33	Abu-Jawdeh dans Plan Bleu, 1999 (117).
Lebanon	Last 20 years	,	,	(7) 15	,	Abu-Jawdeh in Plan Bleu, 1999 (117).
Malta*	1910-1999*	4,800	13,000	36.92	0.41	Maltese ministry of foreign affairs (A. Baldacchino (7))
Tunisia	1972-1994	(8) 9,000	4,952,000	0.18	0.01	Plan Bleu, 2001 (115)
Tunisia	1993	(9) 4,000				Official Tunisian data quoted by Souissi in Plan Bleu, 2000 (118)
Turkey	1978-1998	150,000	27,771,000	0.54	0.03	Huybrechts in Chaline - Plan Bleu, 2001 (24)

* Indicates that the end of the period was not indicated in by the source and that the year of publication was taken arbitrarily.
(1) Around the Great Algiers
(2) Around Nicosia
(3) 35 % probably only concerns the region around Caïro and not the whole country.
(4) Total area affected by man induced soil sealing in France
(5) (Under) estimation of built-up good agricultural land
(6) Very productive agricultural land
(7) Irrigated land
(8) Agricultural gardens around Sfax
(9) Building-up of Tunisian coastal zones.

3. Impact on the soil

One of the most serious consequences of urbanisation is the irreversible destruction of land in areas with strong farming potential or strong ecological value. Such is the case in countries like **Syria**, **Egypt** and **Algeria** where the loss of farming potential makes them more and more dependent on food imports. In city outskirts the development of man-made surface area (industrial and business zones, transport networks and other infrastructures, legal or illegal landfills), extends the destruction of soils well beyond effectively built-up areas.

All the negative effects that urban expansion can have on the lands that it appropriates are well described for the city of Tiaret in **Algeria**. The city began as a military redoubt in 1854 in the heart of a farming region. Between 1962 and 1992 the city went from 40,000 head on a built-up area of about 240 ha to 160,000 head on nearly 3,000 ha (Université de Nice, 1992 [152]):

Box 2: Urban expansion's negative effects on the land for the city of Tiaret, Algeria

"(…) appearance of badlands (...) all around the built up areas of new outlying housing estates and activity zones, around areas of ad hoc Jerry-built habitations (...), areas flooded by industrial or domestic effluents, the building of small, temporary, scattered constructions in the farming outskirts, the use of the woodlands near the city for the pasturing of small herds of country people massing in squatter settlements, the embankments and excavations of new roads... etc. The causes for the mineralisation of the original environment go on forever."

(Source: Université de Nice, 1992 [152])

To this non-exhaustive list can be added the increased risks for city and outlying dwellers (flooding, landslides, forest fires [see Box 3]) as well as the extension of areas contaminated by waste. In **Egypt** for example areas around the main urban areas (Cairo) are used as demolition landfills, mining and quarrying waste, not to mention urban waste (EEAA, 1997 [44]).

Human impact is obviously not the same depending on whether it consumes land with high farming potential or desert areas. As Huybrechts very rightly says (Plan Bleu, 2001 [69]), "It is advisable (...) to go beyond the stage of quantitative analyses of farming or natural land consumption to stress the quality of the space put under pressure." As an example he cites the city of Damascus in Syria where the expansion of urbanisation was done mainly at the expense of the nearby oasis, thus compromising an exceptional resource. Nonetheless the national policy of agrarian reform enabled the creation of new farming areas on hundreds of thousands of hectares in Syria, which would quantitatively have largely compensated the space consumed by urbanisation. As Huybrechts confirms elsewhere (ibid.), "In a flow economy, local analyses lose their meaning." Unfortunately the analyses of the quality of space and making comparisons are only very rarely available. It is worth emphasising that, beyond the quality of the land in question, the magnitude of the negative effects of man-made influence on the land also depends on the urban development modalities underway. Thus, where cities are developed in a non-regulated way, the problems of managing waste, building in risky areas (steep slopes, landslide risks) and pollution are more acute than if national or local policies had been able to confront the magnitude of the needs for housing, land control and slowing the migration from country to major urban areas. Likewise, different kinds of urbanisation and man-made impacts can be imagined, more or less greedy for space, more or less "consuming" land and the environment. Finally, the question of the best to be found can be examined from the point of view of economic rationality between over-consumption, even waste, of excellent agricultural lands by the cities and the major investments necessary for then creating new agricultural lands in not very fertile areas.

Box 3: The increase of risks of "natural" disaster linked to the impact of artificialisation on soils in the Mediterranean Basin

Flooding risks

Land artificialisation implies more or less extensive sealing of the soil, which restricts the infiltration of water into the ground and the replenishment of the watertable s, the whole increasing the quantity of water to be evacuated by run-off. Studies carried out in Israel have shown that while the run-off coefficient represents only 1 to 2 per cent in Karstic areas, cementing them up raises the coefficient to nearly 50 per cent (A. Conacher, 1998 [30]). As an example the city of Dingli in Malta can be cited. For analogous rains it had to evacuate 45,000 m^3 of water in 1968 and 35,000 m^3 more, i.e. 80,000 m^3 in 1988. It is not hard to understand that if adequate provisions are not made for evacuating run-off water in cities and their surrounding areas, man-made modification of the land and especially construction on floodable areas only increases the frequency and intensity of flooding and consequently the magnitude of the damage done by it. We can point to the disastrous floods that hit the southern French town of Nimes on 3 October, 1988 when over 420 mm of rain fell in six hours on the hills that surround the town, causing 11 deaths and 610 million euros' worth of destruction (E. Roose, 1991 [129]). In Italy rains of a lesser magnitude caused considerable damage and a few deaths in Genoa in the winters of 1993-94 and 1994-95 (A. Conacher, 1998 [30]).

In 2001 in Algiers "diluvian rains fell on the capital on Saturday, 10 November and submerged numerous districts of the city, in particular the Bab-El-Oued quarter. (...) Torrents of mud raced down the hills above Bab-El-Oued, sweeping away hundreds of cars and trucks using a steep motorway that leads to this western Algiers suburb." The human toll: on 28 November the Ministry of the Interior announced 757 deaths, 706 of which were in Algiers, and 150 missing persons.

(source: http://www.cyberpresse.ca/reseau/monde/0111/mon_101110040844.html, consulted on 08/01/02).

Landslides

The construction of roads in landscape-sensitive areas can increase the frequency of landslides and amplify the material damage caused. Sometimes with tragic consequences, the development of uncontrolled construction on unstable land located on steep hills near cities can lead to very serious disasters when these lands collapse in heavy rains or earthquakes.

Fire

In Spain the rise in living standards from 1970 on led to an increase in the number of private homes built in pine groves. Simultaneously there was an increase in the number of forest fires (A. Conacher, 1998 [30]). The same thing is well known in France. The multiplication of dwellings in wooded areas increases the number of accidental fires and raises the cost of fighting them. More vehicles and manpower are needed to protect the numerous houses scattered through the woods in cases of fire.

4. What responses to land consumption through artificialisation?

4. 1. The existing responses

Jurisdiction in rural and urban planning, transport networks, tourism and so forth are distributed in very diverse ways, depending on the country, between the national authorities and local communities. In the countries of the northwest shore (France, Italy and Spain) local authorities (regions, provinces or departments and towns) have more power in this sector than in the other countries.

In all countries the State departments or local communities who prepare the development documents are led to consult other social actors such as the representatives of private interests (chambers of commerce and industry, chambers of the tourist industry, farming syndicates and so forth), the other public service departments (e.g. energy, transport, agriculture, the environment), as well as the representative associations (in particular the environmental protection and living environment associations). The "good governance" of the national urban and rural planning process basically depends on the quality and effectiveness of the procedures enabling the participation of all actors concerned. This participation should enable public action to rely on the contributions of all of society's forces.

From the institutional point of view the national and local authorities most often organise their management and development policies by means of plans established at embedded scales, i.e. national, regional, coastal or urban development plans. The hierarchical French system that descends from the level of the national and regional schemes to the schemes of more local consistency (SCOT) and the PLUs (local development plans) is a good example of this. The means implemented to apply these plans include property acquisition, regulations (right of pre-emption, expropriation and so forth) and economics (taxes, subsidies).

4. 2. The main limitations

Over-estimation of the demand: Sometimes, for example in Cyprus or Malta, demand forecasts have estimated needs for land to be urbanised much higher that what was really necessary. Consequently exaggeratedly large "virgin" land areas were conceded for low-density urbanisation.

Poor institutional integration: The institutional integration is too often insufficient between the different decision-making and action levels concerned by urban and rural planning. In certain cases plans are based on purely local analyses that do not make it possible to ensure consistency of development plans at national, even regional, level. At the opposite, in other cases the State defines general action priorities that are not necessarily adapted to particular local situations, and do not leave the actors close to the reality (local communities and others) the responsibility for adapting and carrying out plans.

Limited application of scheduled plans: The relative failure of policies for controlling construction is often related to deficiencies in the application of scheduled plans through lack of means or political will. Thus an international study from the Conservatoire Français du Littoral (P. Bougeant, 2001 [16]) has shown that in the Mediterranean countries of the European Union (Italy, Greece, Spain, France and Portugal) protecting the coastline by law and regulation has had to date only relative effectiveness because the regulations have not been applied.

The existence of extremely strong speculative property tensions and the insufficiency of mobilisation by public authorities can explain the relative failure of development plans. As Huybrechts points out (Plan Bleu, 2001 [69]), in a market economy the price of property increases under the effect of urban pressure. As an example, he cites the suburban areas in Lebanon where the price of farming land is multiplied by at least ten, even a hundred, which completely changes the perspectives for enrichment by the owners of farming areas. By selling a lot at more than \$50 per m^2, they receive more than what they could hope to earn in an entire life of professional activity! It's a problem you find in a number of countries. The influence of immediate economic interests is especially sensitive on the coast, particularly in the tourist sectors. The latter are so strong that often the development plans give tourist works a priority place on the coastline where the developers sometimes confuse natural site and potential tourist sites.

In order to carry out more efficient rural and urban planning it is indispensable that there be better consideration of the constraints related to financial pressures. In some cases it may be interesting to establish measures containing equalisation systems that compensate the loss of property value due to the conservation of natural or farming space. In cases where regulations are not coercive enough and do not carry strong enough obligations, land acquisition remains the best way to engage active protection.

According to Plan Bleu forecasts (Plan Bleu, 2001 [121]), the urbanisation rate in the Mediterranean Basin should go from 64.3 per cent in 2000 to 72.4 per cent by 2025. Faced with these developments and the threats they entail for the environment and long-term development, if governments wish to express a strong political will aimed at keeping non-artificialised spaces and limiting the negative effects of urbanisation, they will have to strengthen their integrated and sustainable policy management of precious natural and agricultural ecosystems. For these policies to be effective, and in order not to reproduce past failures, improvements must in particular focus on:

- a more coherent conception of urban and rural planning,
- a more consequent application of these plans,
- the implementation of tools adapted to land management, in particular to the sustainable conservation of the best agricultural land,
- accrued efforts to enhance the value of suburban agriculture.

PART 3: EROSION AND LOSS OF FERTILITY

1. Mechanisms and causes

1. 1. The various processes

The strictly quantitative aspects of erosion (e.g. by evaluating the loss of soil materials in tonnes per hectare per year) are often separated from the more qualitative aspects (degradation of the structure, a decrease in fertility). In practice they are all closely related.

The mechanisms are often complex. They link natural phenomena (e.g. impact of precipitation, wind, run-off, infiltration, alternating frost/defrost or humidity/desiccation) and harmful human actions (e.g. inadequate tillage, compacting by heavy machinery, non-restitution by adequate replacement of nutrients taken away by harvests, over-grazing, over-exploitation of woodland resources, poorly managed irrigation practices). Depending on their characteristics (e.g. topographical location, pedological type, composition plant cover), the soils are more or less resistant to erosion. One particularly important element is their organic matter content (OM), which has a big influence on the structure of the soil and on its capacity to retain water and nutrients.

In the limited framework of this review it is not possible to describe the diversity of the processes, causes and factors of erosion. Table 4 schematises a few aspects.

1. 2. Geological or man-induced erosion?

At least theoretically, a distinction must be made between "normal" geological erosion due to the natural processes of morphogenesis, which, in the long-run, shape landscapes, and erosion accelerated by humans (anthropogenic), related to the careless exploitation of the environment. The former usually induces losses on the order of.1 to 1 t/ha/yr; on the other hand, the latter can cause erosion from 10 to 1,000 times faster than normal.

A landscape is considered stable when there exists a balance between morphogenesis (erosion speed) and pedogenesis (the speed of rock alteration and soil formation). All that's required is land loss of from 12 to 15 t/ha/yr (i.e. less than 1 mm/yr) to surpass the average alteration speed of rock, thus breaking the balance between morphogenesis and pedogenesis.

It is very exceptional for geological erosion to affect very large volumes of soil. This can however happen in a sudden, disastrous way (the world record being about 100 t/ha/yr in the Himalayas) with rare events such as a succession of very violent downpours or with seismic or volcanic activity. The magnitude of the damage then depends on the state of the soil; it is sometimes amplified by misplaced developments that unbalance slopes (see Box 3). It is very hard fighting this kind of erosion.

Given the millennia-old influence of mankind on shaping the landscape in the Mediterranean Basin, it is impossible to separately quantify man-made and naturally-occurring erosion.

Table 4: The diversity of erosion processes, causes and factors

Degradation and erosion processes and their forms.	Causes and mechanisms.	Resistance factors of the environment.
Degradation through structure loss. Form particular to loessic terrains: formation of slaking crusts	Numerous: mineralisation of organic matter, compaction, and so forth	♦ The structure's resistance depends on its organic matter content, iron, aluminium, flocculated clays and adsorbed cations; ♦ also on the drainage of the watertable and its ionic charge; ♦ compaction depends on the weight of the tools used, tractor tyre pressure and the frequency of passage.
Wind erosion. Forms: ripple marks (micro-rills); Nebkas (micro dunes); mounds at the foot of tufts; dunes; dust clouds.	Wind energy.	♦ Depends on the predominant wind speed and air turbulence. ♦ The environment's resistance depends on the roughness of the soil and vegetation. ♦ The soil's resistance depends on the aggregate structure, soil texture and organic matter content.
Dry mechanical erosion Form: "creeping" (soil particle movement)	Gravity and the displacement provoked by soil-working tools	♦ Depends on the intensity of work on the soil (frequency of tillage and types of tools) ♦ Depends on the slope and soil cohesion.
Sheet erosion. Varied forms depending on whether it is an ablation or sedimentation area.	Rain drop impact and the sheer stress from sheet wash	♦ Plant cover ♦ Slope ♦ Soil nature ♦ Soil conservation techniques and facilities
Vertical erosion. Forms: rills, gullies	Concentrated run-off. Its energy depends on the volume and the square of its speed.	♦ Erosion speed depends on the slope and terrain roughness. ♦ The run-off volume depends on the watershed area and the capacity of infiltration. ♦ Resistance depends on soil profile and the roots grid.
Mass erosion Form: creeping (soil movement), sliding; mud flows.	Gravity, slope imbalance.	Aggravating factors: ♦ Weight of the soil + water + plant cover; ♦ wetting of the sliding plain; ♦ topography: existence of pitch parallel to the slope; the presence of impermeable levels or "slippery layers".

(Source: based on E. Roose, 1991 [129])

1. 3. The main causes of soil fertility loss: inadequate farming practices

Often poorly put issues: population density and farming intensity

Some experts claim that an increase in population density leads almost automatically to an increase in erosion; they found their arguments on the fact that in any given agrarian system, if the population exceeds certain limits, land becomes a scarce commodity and the threshold of fertility-restorative mechanisms is crossed. This can then lead to accelerated and irreversible degradation of the soil. Yet these experts ignore the fact that demographic growth can generate "progress, innovation and adaptation" (G. Rossi et al., 2000 [131]) and that, beyond certain population thresholds farmers are forced to change their production systems to find a new balance between exploitation of the soil and their restoration. But this new balance is often costlier in investment and work than the previous (E. Roose, 1994 [128]).

Likewise, the intensification of agriculture is generally regarded as one of the main causes of soil degradation. Indeed in too many cases, especially around the Mediterranean, a poorly carried out intensification of the technological itinerary has led to the loss of many hectares. Mechanisation has enabled the tilling of certain fragile, marginal areas that cannot tolerate an intensive tilling rhythm. The over-use of chemical fertilisers has often led to a mineralisation of the organic matter and a degradation of the structure of certain soils, all leading to a loss of fertility that is irreversible in the most extreme cases. To attain its goal in a sustainable way, the goal being an increase in productivity, intensified production must integrate all necessary practices for maintaining the soil's fertility. When the intensification manages to do this, it must then be considered to be a good solution for ensuring soil conservation and the sustainability of productive exploitation systems (E. Roose, 1994 [128]). Production intensification is therefore not a factor of degradation in itself but can become one when it is poorly managed. In the opposite sense, irrational extensification can wind up abandoning good conservation practices and consequently lead to a loss of soil fertility and its potential productivity.

Erosion and fertility loss: the outcome a land-use system not adapted to the physical and above all to the social and economic contexts

The occurrences of accelerated erosion, too often seen in the Mediterranean Basin, are not the inevitable consequence of accrued demographic pressure or the intensification of farming methods. They are related to certain modes of development that unbalance the agrarian ecosystem, i.e. clearing and the tilling of areas with fragile soils, soil exhaustion by intensive tilling without compensation by the addition of organic matter and nutrients, over-grazing and over-exploitation of forestry resources (E. Roose, 1994 [128]).

The history of soil use shows that the major erosion crises in the Mediterranean often go hand in hand with the evolution, even the destructuring, of the agrarian systems. Thus at the end of Antiquity in North Africa, the arrival of the nomads and the development of cattle raising and extensive tilling progressively caused the abandonment of works for conserving water and soil that up till then made intensive cultivation of vines and fruit trees possible, even on sloping terrain. The de-intensification of agriculture was then, according to (W. C. Lowdermilk, 1948 [85]), the root cause of an accelerated erosion that went together with the decline of the Roman Empire. The same type of scenario (the abandonment of good conservation practices because of the development of extensive cattle-raising) would be, again according to Lowdermilk, the triggering mechanism for the irreversible loss of land in Jordan (around Petra), Israel and Syria ("the 100 dead towns"). However certain experts (Marchand, 1990) tend to relativise the misdeeds attributed to the nomads.

Nowadays it is rather the reverse phenomenon (i.e. the intensification of the exploitation of marginal lands) that in these same regions sometimes dramatically accelerates erosion. In contrast on the northern shore of the Basin the spontaneous biological return towards woodlands, which generally follows on agricultural abandonment, has led to a halt in the erosion processes that were described as disastrous (e.g. the southern French Alps). In any case, present or past, it is the evolution towards agro-sylvo-pastoral practices that are not adapted to the soils that leads to soil degradation (see Part 1, Chapter 2). The consequences for soils and the environment in general are all the more important because social mutation is rapid and the provisions for ensuring the creation of a new sylvo-agro-pastoral balance are not made quickly enough.

Table 5: Changes in land use in Italy from 1967 to 1990

	1967		1990		Difference between 1967-1990	
	Area (ha)	% of total	Area (ha)	% of total	Area (ha)	% of total
Annual crops	12,389,216	41.1	8,129,732	27.0	-4,259,484	-14.1
Perennial Crops	2,824,218	9.4	2,787,359	9.3	-36,859	-0.1
Pastures	5,165,660	17.1	4,128,808	13.7	-1,036,852	-3.4
Other arable land	1,031,291	3.4	2,040,919	6.8	1,009,628	3.4
Forests	6107,013	20.3	8,675,100	28.8	2,568,087	8.5
Other uses	2,608,340	8.7	4,363,820	14.5	1,755,480	5.8
Total national area	30,125,738	100.0	30,125,738	100.0	,	,

(Source: PAP-RAC, 2000 [145])

According to Tayaa *et al.* (ICALPE, 1992 [70]), in the eastern Rif of **Morocco** to the north of Nador province, old grazing lands were cultivated for feeding an ever denser population. This led to the increase of badlands and the deepening of torrential channels - except where stone walls still retained the soil and limited water concentrations. In all, between 1966 and 1986 in the north-eastern part of the Rif, the surface area of cultivated lands increased by 92 per cent while the surface area of woodland and mattoral decreased respectively by 42 and 38 per cent. Likewise on the coastline, tilling, which broke the upper part of ancient consolidated dunes, accelerated the wind processes and led, after many years of rigorous drought, to the formation of veritable nebka fields in the Guerrouaou basin. Other examples have been cited in Morocco where the illegal cultivation of Indian hemp (from which about 200,000 people are said to live) extended up to often-fragile sloping land and led to the general spread of gullying.

Table 6: The evolution of land use in three representative areas in the central-western Rif (Morocco) between 1966 and 1986

	Forests			Matorral			Crops			Cultivated land
	1966 (ha)	1986 (ha)	Difference (%)	1966 (ha)	1986 (ha)	Diff. (%)	1966 (ha)	1986 (ha)	Diff. (%)	% in 1986
Zone 1	11,099	4,032	-63.7	59,785	31,609.0	-47.1	40,519.0	75,762	87.0	26.0
Zone 2	27,648	19,912	-28.0	79,220	52,574.0	-33.6	36,386.0	70,768	94.5	26.0
Zone 3	8,399	3,412	-59.4	11,969	9,633.0	-19.5	5,879.0	13,202	124.6	31.0
Total	47,146	27,356	-42.0	150,974	93,816.0	-37.9	82,784.0	159,732	93.0	27.6

(Source: ICALPE, 1992 [70])

In **Tunisia**, a case study was carried out (K. Louhichi, 1997 [84]). It concluded that the recent and rapid evolution of the socio-economic environment of the rural world has led to: 1) the clearing of certain marginal or grazing plots, and their cultivation to meet the needs of a constantly growing population; 2) an over-exploitation of the remaining pastures, which has led to their fragilisation; 3) inadequate mechanising of cultural practices (e.g. tilling the slope vertically, degradation of the soil structure); 4) the abandonment of traditional conservation measures that led to erosion of formerly protected soils; 5) the lack of monitoring and maintenance of conservation structures developed within the framework of the first water and soil conservation strategy programme; with the result that these structures have degraded over the years because of lack of maintenance.

The evaluation of the soil quality and its aptitude for being subject to various types of use is a necessary preliminary for conservation and planning programmes. Very important study has been carried out in **Turkey** where soil classification and soil and suitability mapping have been established. The soils belonging to the best suitability class possess good potential for a whole range of uses, while the "poorly rated" soils have serious limitations for cultivation and require heavy investments. This study highlighted the frequent lack of overlap between soil potentialities and their uses; there is both the under-exploitation of the best soils and over-exploitation (thus degradation) of the poorer agricultural land. This study shows that agriculture in the way it is presently being practised wastes soil resources (C. Kangir, 2000 [19]). In particular water and wind erosion are generally the most present where extensive agriculture is practised, whereas they could be reduced if the users had the means to intensify their agriculture adequately.

In contrast an example of badly led intensification can be given in France[2] in an area of small mountains and hills on the southern side of the Massif Central, in the area of Rougiers de Camarès in southern Aveyron. 80 per cent of the land is affected by water erosion. This sensitivity to erosion is due to aggressive natural conditions but has been exacerbated by farming intensification over the past few decades, i.e. mechanisation, shortened crop rotations, frequent tilling of the soil, the re-allocation of land and suppression of hedgerows, the clearing and tilling of marginal lands with shallow soil and steep slopes (ORSTOM, 1998 [135]). The French researchers from the French Institute for Research and Development (IRD) have shown that run-off and erosion on plots can be limited through regular additions of compost or crop residues to the soil as well as the introduction of fodder or green manure in the crops rotations. Likewise, direct sewing and surface tillage, which concentrate organic matter on the surface, would be more favourable than conventional tilling, which buries them. The intensification in this area was badly led; it should and could still be corrected. Here too, it is the modalities of the intensification rather than the principle itself that are questioned.

Box 4: The abandonment of often effective traditional techniques is related to the change in the social and economic context of a country

M. Roose et al. in an article written for the IRD (formerly ORSTOM) in 1998 wrote:
"To cope with soil degradation problems, rural societies have developed water management and soil fertility strategies the effectiveness of which is related to the physical environment or even more to local socio-economic conditions. For example, "cut-and-burn" farming is known on the 4 continents; it is a non soil-destructive method as long as the population does not exceed from 10 to 40 head per km² in a subsistence economy. From 10 to 50 fallow years are necessary for reconstituting the fertility of a soil that cultivated from 2 to 5 years after burning. As soon as the landownership pressure increases because of the growing population needs, the soil's rest period is shortened, and fertility drops. At the other extreme are found the graded terraces developed over centuries around the Mediterranean. They appear only where flatlands are lacking, where salaries are low and manpower abundant. As between 1,000 and 1,500 days of work are needed to build terraces on one hectare, the latter are only built where there is strong demographic, military or religious pressure and where crop profitability is high (frequent irrigation).
In Tunisia Bonvallot (1986) studied the traditional system of the 'jessours', earth dikes that make the construction of tiny, multi-stage gardens possible by collecting silt-rich water at the bottom of arid valleys after it runs off slopes. (...)
These often very efficient traditional techniques have now been abandoned for they can no longer meet present demands, i.e. the population has multiplied by 5 since the turn of the century and is doubling every 25 years; monetary needs have increased a lot, and the work of soil conservation is not profitable in the short-term."

(Source: ORSTOM, 1998 [135])

[2] Communicated personally by Mr. Roose

2. The extent of the phenomenon

2. 1. A lack of data about losses of soil fertility

The data on soil degradation that are found in documents are usually only about water and (sometimes) wind erosion. Compaction by machines, degradation of the soil structure and texture and losses of biological quality of the soils have only rarely been studied and are therefore little quantified, especially on a national scale.

Reference standards are generally lamentably lacking today. Measurement and evaluation methods are complex; their results should be interpreted according to spatial and temporal scales to which they refer. The general public doesn't have access to these interpretations, which explains the false ideas and clichés that so easily result from going public with excessive figures. Even the figures relating to water erosion only give relative indications as to the phenomenon's magnitude. They are from very diverse origins, and given the multiplicity of the methods for measuring and calculating erosion, they are hard to compare from one study to the next. The figures given later in this study correspond to information found in the documentation and do not accord between them or with the figures given by the FAO (see Map 5).

2. 2. Elements on the magnitude of erosion

The most frequent kinds of erosion seen in the Mediterranean Basin are soil truncation, gullying, landslides and the bank undercutting (E. Roose, 1991 [129]). Gullying is especially intense in soft formations where it creates badlands. Examples are the black marls in the southern French Alps, the sandstone in the Ouarsenis, the "calanchi" in the Italian Apennines (Y. Veyret et al., 1998 [158]). Landsliding can occur when there are slippery layers on slopes that are not even necessarily steep; examples are known in the humid coastal mountains of the North African countries, the central Rif and further south in the Aures, not to mention the French Alps (Trièves) and Italy where the "frane" are unstable slopes that periodically begin to move (Y. Veyret et al., 1998 [158]). In the regions closest to the sub-arid range the alternation of dry and wet phases provoke, with the heat helping, the formation of screes. The rare but violent rains carry them away in the form of muddy flows that invade inordinately widened valleys but with very narrow alves (J. Bethemont, 2000 [14]).

In Morocco a study by Heusch, quoted by Roose (in E. Roose, 1991 [129]) is based on a geomorphological analysis to forecast the risks of soil loss according to the type of erosion. The following orders of magnitude emerge:

Table 7: Orders of magnitude of soil losses due to various types of erosion

Type of erosion	Order of magnitude of losses (t/ha/yr)
Sheet erosion	1
Interril erosion	10
Gully erosion	100
Landslides	1,000
Bank undercutting	10,000

(Source: based on Heusch cited in E. Roose, 1991 [129])

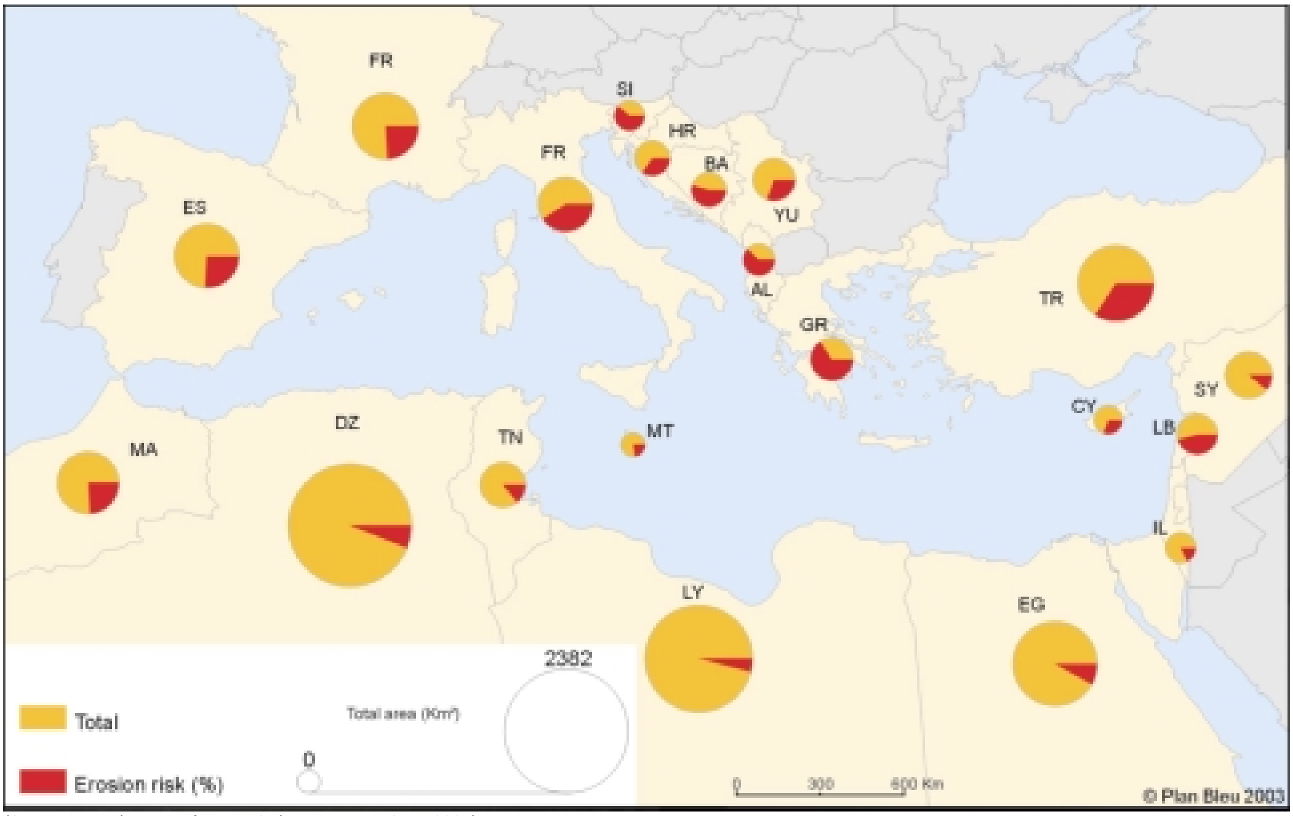
N.B. the number of hectares in question varies in inverse proportion to the types of erosion mentioned. Rills, gullies and undercutting are linear not surface phenomena.

These orders of magnitude are not totally confirmed by the analysis of the mapping of the forms of erosion in Morocco (Morocco, [87]); nonetheless they indicate large discrepancies between the different types of erosion: 800 t/ha/yr for bank undercutting; 80 t/ha/yr for gullied areas or subject to soil creep; 5 to 6 t/ha/yr for slopes subject to sheet erosion.

Wind erosion mainly concerns arid and semi-arid areas.

By grouping together the various types of mechanical erosion, the FAO estimates that in all about 15 per cent of the national land rimming the Mediterranean are concerned by erosion (TERRASTAT).

Map 5: Surfaces threatened by erosion in the countries of the Mediterranean rim (%)



(Source: map drawn up from FAO data, TERRATSAT, 2001)

In Tunisia an erosion map drawn up in 1980 shows that of the 5.5 million mapped hectares, 1.3 million were affected by erosion, of which 740,000 ha moderately to severely. The Tunisian national water and soil conservation strategy mentions that 3 million hectares, or a fifth of the country, are subject to the risk of water erosion, half of which is highly threatened.

Risks of erosion in Turkey, according to certain estimations (Prime Ministry State Planning Organisation, 1998 [143]), affect about 81 per cent of the nation to differing degrees, including about 466,000 km^2 for wind erosion (or 61% of the nation). The NEAP estimates that in all on average a billion tonnes of soil are lost annually in Turkey through erosion.

In Israel soil loss through erosion varies between 0.27 t/ha/yr in the Karstic areas of the northern basins and 1.85 t/ha/yr in the country's southern regions covered with loess. A large part of the sediment is carried off by winter floods (Y. Gradus et al., 1996 [65]).

In a study carried out for the CIHEAM (26), Skouri defined desertification as "the final stage of the degradation of the natural milieu expressed on the one hand by the disappearance of the plant cover and on the other by an acceleration of the erosion processes engendering an increase of the aridity of this milieu and a drop in soil fertility". He cites the estimates calculated by H. E. Dregne in 1984 on the basis of the compilation of national data that show that generally speaking about 80 and 30 per cent of the pastoral farming land is more or less affected by desertification respectively in the south and the north of the Mediterranean. The difference between the two is mostly explained by the fact that the arid and semi-arid areas (the most vulnerable to desertification) cover the major part of the southern and eastern Mediterranean lands while there are few of these kinds of areas in the European rim countries with the exception of Spain where they cover 80 per cent of the country and a much lower proportion in Greece.

Table 8: Land affected by desertification in the Mediterranean region (1984)

	Mediterranean Africa		Mediterranean Europe	
	Surface area (millions of ha)	% affected by desertification	Surface area (millions of ha)	% affected by desertification
Grazing land	68.0	85	15.0	30
Rain-fed crops	15.0	75	13.0	32
Irrigated lands	0.5	40	1.6	25
Total	**83.5**	**83**	**29.6**	**31**

(Source: Based on Dregne quoted by Skouri, CIHEAM, 1993 [26])

2. 3. Elements on the degradation of the soil structure and loss of organic matter

In Italy soil compaction is the main type of soil degradation, especially in the Po Plain and along the Adriatic coast (Italia, Comitato Nazionale per la Lotta alla Desertificazione/ Italia, Ministero dell' Ambiente, 1999 [73]). Organic matter loss is mostly localised along the Adriatic coast and in southern Sicily. There are many reasons, mainly farming-related: monoculture, the elimination of plant residues, over-intensive working of the land which provokes the dispersal of the structure and excessive aeration and consequently the mineralisation and oxidation of organic matter.

In France, according to the IFEN (IFEN, 1999 [71]), the surface areas concerned by compaction are impossible to evaluate with precision but are clearly increasing due to the increase in mechanisation and the use of ever heavier harvesting machines as well as the decrease in organic matter input. Local studies demonstrate a significant reduction in the ratios of organic matter in cultivated soils over the past few decades. There are few data on the French Mediterranean milieu, but the existing data indicates low percentages (from 0 to 25% (IFEN, 1999 [71]). This drop is essentially due to the intensification of tillage, irrigation, the reduction of perennial fodder for the sake of annual fodder or grains as well as the abandonment of tilling with animal traction and the lack of compost in the fields.

3. The impact

3. 1. The difficulties of evaluating the impact

The spatial dimension

Erosion implies the transfer of matter and sometimes fertility from one place to another. Impact varies; on the one hand there is the place itself where the erosion occurs (on-site impact) with the ablation of materials, and, on the other, on the locations where these materials are deposited (off-site impact). The latter are found downstream in the watershed (water erosion) or in the lee of the predominant winds (wind erosion). From an economic point of view upstream is askew from downstream, i.e. land users suffer direct losses due to degradation that occurs on-site, whereas they seldom suffer the consequences of degradation downstream of their plots.

The time dimension

Except for exceptional geological events, erosion is a relatively slow phenomenon on the human scale. Depending on the magnitude of the phenomenon, the effects of erosion are felt more in the middle- and long-term. The problem of erosion thus introduces a conflict between immediate priorities and long-term vision of sustainability to the detriment of future generations. Indeed the over-intensive exploitation of a soil can make it produce a lot for a few years, then exhaust it beyond all use, rendering it unproductive for future generations.

A diversity of criteria

Erosion's negative effects can be measured by different criteria, particularly in terms of the following:

- Loss of soil depth. It can be inexorable when the speed of erosion is greater than the speed of soil replenishment. The weathering speed of the parent rock varies from between 1 to 12 t/ha/yr, depending on the pedogenesis processes, which themselves depend on the climate, the nature of the rock and the type of plant cover;

- Loss of land productivity. It is observed when, with other conditions being equal, yield diminishes from year to year; or - which amounts to the same - when maintaining yield requires greater and greater input levels;

- Loss of environmental quality. Degradation of the plant cover; downstream water quality is degraded, and alluvial deposits may diminish the capacity of natural or artificial water capture or cover fertile soil with sterile elements.

The magnitude of physical impact depends, among other things, on the soil type and its resistance to erosion. As for social and economic impacts, they also depend on present and potential uses of the soil. The degradation of very productive soils is more serious than that of soils whose farming or ecological potential is low.

A soil's vulnerability to erosion depends on its cohesion, its protection against rain by a plant or pebble cover and the hardness of the substrate. Cohesion is furthered by high organic matter content and the presence of flocculent chemical elements such as clays and other colloids. In contrast, the presence of dispersing agents such as sodium is harmful. In general the Mediterranean soils are fairly resistant to wind and water erosion. This resistance, however, can be reduced by over-grazing or by exploitation without any input of organic matter. In such cases the ground compacts and can develop slaking crusts, especially if the soil is loamy. In all cases run-off increases; it remains clear as long as the water is slowed down by clods, pebbles or tufts of grass; then the water loads up with sediment as it gains speed because of the slope and the volume of run-off; at the same time it concentrates in rills (sediment load from 5 to 20 grams per litre), then in gullies and wadis (load from 20 to 200 g/l) (E. Roose, 1991 [129]).

The soils of the semi-arid dry fringes of the Mediterranean world are precariously balanced, mainly because of their low water holding capacity and the high rate of evaporation. In these sectors the soils are especially sensitive to changes in the plant cover, which is their major source of protection.

3. 2. On-site impact

The negative effects of on-site erosion are essentially the loss of productivity of the soils. This loss remains minimal as long as the soil is deep but becomes especially serious on shallow soils (E. Roose, 1994 [128]). Sometimes the loss of soil productivity can be immediate through loss of cultivable surface area, e.g. if the fields are no longer accessible to machines because of the gaping nature of gullies. In general, however, the loss of productivity has middle- to long-term effects. Sheet erosion, even if it generally does not carry off large volumes of soil, first washes away the soil's fine elements, which are often the most fertile. The loss of soil fertility can usually be corrected with inputs and is therefore limiting in the short-term only with poor users who cannot pay for these inputs. For them the loss of marginal production, but vital for their survival, is extremely penalising. In fact, "the impact of erosion is more important for the small farmer who will be marginalized for lack of credit, spirit of initiative or know-how. They cannot respond unless they radically change their production systems (high-profit production). A vicious circle of impoverishment for the poor and the search for new solutions for those with the means!" (E. Roose, 1991 [128]).

Apart the loss of fine elements (often the most fertile), the other consequences of on-site wind erosion are abrasion, corrosion and deflation.

The loss of fertile elements is not easy to quantify, especially because it is often related to relatively small losses in volume. Yet in **Morocco** the problem is seen as the most serious threat for potential productivity in agriculture. While remaining very careful about the reliability of their findings, Moroccan experts estimate that the losses of fertilising agents are the equivalent to about 5 per cent of the cultivable surface area (Morocco, 1995 [88]).

Box 5: The negative economic consequences of water erosion on-site

• Immediate losses of water, fertilisers and pesticides;

• Immediate production loss on the following levels:

regional:	*2 to 10% of production: compensation possible in relation to input*
local:	*2 to 50 % = single disaster = loss of profit margin*

• Loss of cultivable surface area on the following levels

global	*7 to 10 million/ha/yr,*
regional...	*up to 2 to 5% of the cultivable surface area*
plots...	*up to 20 to 100%*

• Long-term productivity losses

Reduction of the depth of the humus horizon
Reduction of water and nutrients storage
Reduction of the effectiveness of rain and inputs
Reduction of profitability

(Source: based on E. Roose, 1994 [128])

3. 3. Impact downstream of the eroded site

This impact is the result of sediment transportation. As a general rule sediments degrade the quality of the water that carries them because of the presence of a more or less large masses of suspended mineral or organic matter and by the frequent presence of pollutants related to this matter (e.g. phosphates, pesticides, heavy metals.). When they are deposited, they reduce the carrying capacity of the streams (thus increasing the risks of flooding), drainage ditches and irrigation canals; they also reduce the storage capacities of natural or man-made reservoirs. Several hydroelectric or irrigation structures have been ruined because of the erosion of an upstream watershed.

Box 6: The negative economic consequences of water erosion downstream of eroded locations (off-site)

• Degradation of water quality:
- increase of suspended sediment (SS);
- river pollution;
- water eutrophication and dead fish;
- cost increase for treating potable water.

• Sedimentation:
- silting up of reservoirs and other hydraulic works;
- silting up of ports and some coastlines;
- reduction in the capacity of evacuating floods by streams and ditches.

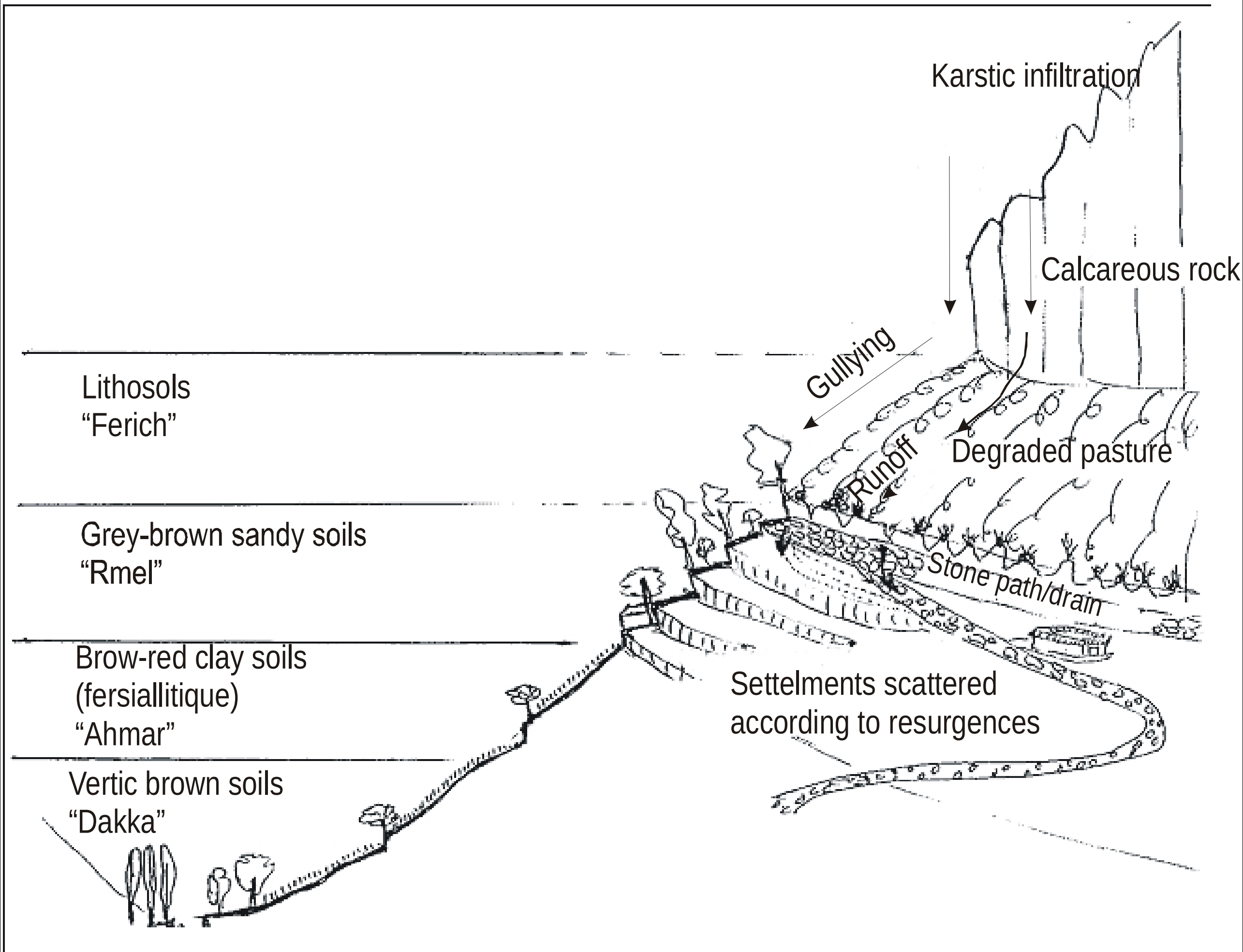
• "Natural" disasters:
- increase of peak river flows;
- flooding of inhabited areas;
- mud flows;
- destruction of works of art, bridges and so on.

(Source: based on E. Roose, 1994 [128])

The magnitude of the downstream impact of the erosion obviously depends on the volume of sediment carried as well as the sensitivity of the facilities concerned.

In some cases the consequences of erosion may even be seen as beneficial, e.g. when the deposited sediment plays an amendment role. The fertilisation of Egypt by the flooding Nile (up until the building of the Aswan Dam) is a famous example from antiquity. On a smaller scale, an ORSTOM survey in Morocco described an interesting system where farmers used upstream erosion and run-off to fertilise their lands downstream.

Figure 2: Sketch profile of the slope at Bettara (Moroccan Rif)



Agroforestry in valley	Extensive crops (cereals - olive orchards)	Terraced gardens	Degraded pastures
Irrigation	Impluvium	Irrigation	Impluvium

(Source: based on E. Roose et al., 2000 [130])

In **Italy** estimates have been made on the average silting up of reservoirs (Chisci and Basoffi cited by Andrea Giordano in PAP-RAC, 2000 [145]). Major dams annually lose up to 1 per cent of their capacity in certain wooded and farming regions. The smaller dams lose an average of 0.3 per cent in wooded areas and 2 per cent in intensive farming areas. A survey of 268 Italian dams shows that 1.5 per cent of them have completely silted up, 4.5 per cent have had their capacity reduced by more than 50 per cent, and 17.5 per cent have lost more than 20 per cent of their capacity (PAP-RAC, 2000 [145]).

In **Morocco** sedimentation is the cause of considerable reduction in the lifespan of dams (see Box 7). It is also a cause of the degradation of certain vulnerable and protected areas, i.e. the pollution of coastal lagoons by pesticide-infested sediment, spread over nearby lands endangers their fragile ecosystems. (Morocco, 1995 [88]).

Box 7: The magnitude of the silting up of dams in Morocco in 1995

The silting up of dams increases each year by 50 million m^3, or 0.5% of the total storage capacity of 10 billion m^3. This is the equivalent of the silting up of a dam every 2.4 years, if we consider that the average capacity of a dam in Morocco in 1995 is 120 million m^3 (figures calculated from data gathered by Plan Bleu, 1999 [86]). All dams older than 20 years are silted up by more than 10% of their initial capacity. Capacity lost by the large retention dams now surpasses 820 million m^3. The silting up of dams could rise to 100 million m^3 per year if erosion worsens through increased demand on soils and the plant cover under the effect of demographic pressure and irrigation. The loss of production by hydroelectric plants because of silting up was put at some 60 million kWh in 2000 and could reach 300 million kWh by 2030. Forecasts for the reduction of potable and industrial water availability were about 40 million m^3 per year in 2000 and could be over 200 million m^3 per year by 2030. Lastly the reduction of dam capacity each year leads to a loss of irrigated surface areas equivalent to about 5,000 ha.

(Source: Morocco, the Ministry of the Environment, the Moroccan National Observatory of the Environment (ONEM) / ECODIT, 1995 [88])

Box 8: Examples of annual cost calculations for erosion in Morocco

In Morocco analyses have focused on the costs due to erosion, the silting up of dams and losses of farming productivity. These costs vary greatly depending on the sites and the farming regions.
The annual cost of farming losses was calculated as the difference between the theoretical net income per hectare and the net income with erosion. Figures vary from between 2 and 152 Dirhams/ha/yr (about 0.2 and 15.2 $/ha/yr) depending on the region.
The costs of silting were estimated by comparing a situation without silting acceleration to a situation with silting acceleration. This cost was calculated as the value of lost production downstream (e.g. farming, energy) as long as the site is not threatened and as the value of the investments needed to re-establish the dam functions when silting reaches critical thresholds. Simulations up to 2030 have been carried out to gauge the impact of the silting of each site. There too the results are very variable depending on the dams, their silting cadence and the cost of de-silting when it is necessary. The figures found vary from 0.38 to 10.5 Dirhams/m^3 over a 40-year period (1990 to 2030), or 0.038 to 1.05 \$/m^3.

(Source: Morocco, 1995/1999 [87])

Table 9: The silting up of dams in eastern Algeria

Basins	Wadi	Dam	Basin surface area (km^2)	Average rainfall (mm)	SS content C (g/l)	SD (t/ha/yr)	Total silting time
Saf Saf	Saf Saf	Zardezas	300	863	5.0	12.50	20 yr
Garaet el Tarf	Guiess	Foum el Guiess	156	520	9.3	6.70	27 yr
Djen Djen	Djen Djen	Erraguène	134	1 350	23.0	22.0	3 yr
Chelif	Mina	Bakhadda	1,300	500	5.6	3.10	16 yr
Chelif	Chelif	Ghrib	2,800	345	33.0	1.7	29 yr

(Source: Y. Veyret, 1998 [158])

C represents average content in suspended sediment (SS) of water arriving at the dam
SD, specific degradation, is the volume of average annual erosion in the catchment area.

3. 4. Impact of wind erosion

Wind erosion produces the formation of regs and sand bar formations downwind from the eroded site. The problems of sanding up have become acute in the arid and semi-arid countries, especially in North Africa (see Box 9). In **Morocco**, the palm groves threatened with silting are put at 30,000 ha for 80,000 inhabitants in Ouarzazate province and at 25,000 ha for 200,000 inhabitants in Errachidia province (Morocco, Ministry of the Interior, 1993 [90]).

Box 9: The localisation of sand bars in North Africa

*In **Morocco** sand bars are developing especially in the south and southwest of the country: i.e. to the east of the High Atlas in the middle Ziz and Lower Ziz basin, around Errachidia, Goulmina and Erfoud, and to the south in Tafilalt, the Draa basin, the areas of Ouarzazate between Xabora and Mohamid el Gozlam, then particularly in the Tarfaya-Laayooune area.*

*In **Algeria** outside the Saharan area, the high plateaux that are the most affected by sand bar formation. 500,000 ha of wind formations stretch to the north of the Saharan Atlas in the three endorheic basins of Chotts Chergui, Zahrez el Gharbi, zahrez el Chergui and Hodna. The largest of the dune chains thus formed attains 200 km in length, 5 to 7 km in width and 15 m in height; it is composed of very mobile active dunes that displace a great amount of sand.*

*In **Tunisia** the areas most affected by sanding up are the pre-Saharan and the Djeffara. But after the flooding of 1969, dunes also formed in the Kairouan region.*

*In **Libya** the northwestern coastal area is the most affected, in a line from Djeffara and the central area of the country.*

*In **Egypt** the sensitive areas are concentrated around the oases of the western desert and the eastern desert between Port Said and Suez.*

(Source: G. Coude-Gaussen et al., 1995 [31])

4. Responses to erosion and fertility losses

4. 1. Technological responses

The technological methods of fighting erosion can be divided up into three categories depending on whether they are based on soil management, operations with heavy machinery or the use of vegetation.

Soil management

The goal of methods based on soil management is to improve the ways to prepare the soil so as to improve its resistance to erosion. They include the addition of fertilisers and organic matter to improve structure and chemical fertility (R. P. C. Morgan, 1996 [96]). Spraying the ground with stabilising compounds such as oil or ground bark are measures used for protecting soils against wind erosion. (R. P. C. Morgan, 1996 [96])

In **Tunisia** several cultural techniques have been used to limit the risks of erosion on arid lands, e.g. the replacement of disk ploughs by stubble ploughs or a pronged tool; the blending of working the soil with the addition of plant residues to improve the soil roughness; tilling perpendicular to the active predominant winds where wind erosion is the greatest (G. Coude-Gaussen et al., 1995 [31])

Mechanisation

These techniques are based on terracing work (bench terracing, terracing, dams, ditches, gully protection structures, jessours, meskats and so forth) to remodel the ground surface in order to slow run-off, hold back sediment and facilitate water infiltration into the soil. On their own they are not enough to stop the process of particle detachment from the soil. Revegetation is a vital complement.

In **North Africa** the policy of soil defence and restoration (DRS) has implemented vast networks of bench terracing comprised of a strip of crops, a ditch and an earth bank. These works involved 375,000 ha in **Algeria**, 100,000 ha in **Tunisia** and 300,000 ha in **Morocco** between 1960 and 1990 (Y. Veyret et al., 1998 [158]).

Crop and vegetation management

These techniques use vegetation for protecting the soil against erosion, improving its structure and, thus, its fertility. To stop the degradation of the plant cover and promote its restoration there are several possible solutions depending on the nature of the cover and the causes of degradation.

When it is a matter of agricultural land, these measures combined with good soil management can reduce particle detachment and transport. Among the best known techniques are: mulching, crop rotation and the maintaining of strips of vegetation (natural or otherwise) between crop rows. Common solutions against wind erosion are shelterbelts and windbreaks (R. P. C. Morgan, 1996 [96]).

The fight against the degradation of woodland space includes the precise definition of land rights and user rights, forest planning according to the principles of sustainable management, the fight against over-grazing and the over-exploitation of fuel wood (including the development of energy-saving ovens or by substituting alternative energy sources for wood), limiting the felling of woodlands for crops and towns (in particular by land-management policies), the defence against fire and, in certain cases, reforesting (J. de Montgolfier, 2002 [94]).

Natural vegetation regeneration on grazing land can be achieved by reducing the animal load, or even, on very degraded land, by totally banning grazing for a more or less extended period (deferred grazing area). This measure is effective to varying degrees, depending on the state of the vegetation degradation and the nature of the substrate. In **Tunisia** deferred grazing on the steppe is effective in sandy areas whereas it is not very effective on gypsiferous crust or silty fan, for the presence of crusts limits the chances of successful regeneration. In Bengardane and Chahbaniaby deferring grazing of nebkas to fix the sand has made it possible to increase the production of grazed annual species by 42 per cent and to multiply by 5 the production of perennial species. Deferring grazing on steppes still in good condition had no influence on the production of annual species but it did make it possible to multiply by 5.3 the production of perennial species (G. Coude-Gaussen et al., 1995 [31]).

The choice of techniques

When a soil is degraded, the problem to solve is rarely simple. On the contrary, there are usually interactions between a raft of complex phenomena (a drop in the ratio of organic matter, structural degradation, fertility loss, dry mechanical erosion, sheet erosion, gullying and landslides) themselves due to the complex interactions of physical, social and economic processes, some of which occur upstream. To effectively fight degradation a serious analysis must be done of all the ins and outs of erosion, and there must be a clear vision of stakes and objectives.

Since erosion is a natural phenomenon it is not desirable or even possible to get rid of it completely, but it should be limited to a "tolerable" level (E. Roose, 1994 [128]) (see Box 1). What is tolerable is often hard to determine; it varies according to the types of soil and the uses made of or planned for it. The accepted tolerance threshold determines the moment when intervention becomes necessary as well as the kind of response to make. It is often the case that soil conservation must be done by using several combined measures (e.g. soil and crop and vegetation management).

The choice of techniques to apply obviously depends on the type of soil (e.g. the pedological nature, physical and chemical characteristics, slope, exposure). For example bench terracing can be very effective on alluvial soil subject to short, violent storms but may prove to be harmful on quickly saturated clay soils. In this latter case it increases the risks of landslide, the gullying of outlet channels and the undercutting of banks downstream.

In choosing techniques major attention should also be paid to the social and economic context; the use to which the soil will be put must be taken into consideration (is the land to be cultivated or, on the contrary, is it unproductive land that has to be stabilised to prevent damage downstream?), as should the means available for ensuring the execution and maintenance of the works (the presence of sufficient manpower, financial means) and especially the motivation and predictable behaviour of its future users.

For projects to be effective, they must be maintained over time, failing which they can be the cause of even greater degradation than if they hadn't existed in the first place (mechanical works in particular require sustained maintenance). In practice only a participatory approach, effectively associating users with the design and implementation of the works, ensures their sustainability and their long-term effectiveness (J. de Montgolfier, 2002 [94]).

4. 2. A history of conservation strategies

The various civilisations that have followed one another down through the centuries around the Mediterranean have, within the framework of their agrarian systems, applied soil conservation measures that have been more or less elaborate and more or less effective. Starting in the middle of the 19th century, certain modern States began implementing soil conservation policies. These State policies generally reached their peak in periods of centralised, authoritarian or colonial power. What is often seen today is disengagement by States and an increase in participation by local authorities.

The restoration of mountain lands

The principle of restoring mountains lands was established in France in the latter half of the 19th century and was at first administered by the Ponts et Chaussées, then by Eaux et Forêts to restore mountain soils degraded by over-grazing, over-exploitation of timber or the tilling of overly fragile soil. The main objective was to protect against disastrous flooding in cities and protect transportation routes and farming lands located downstream of catchment areas where erosion was the most active. A pre-condition for the work was the expropriation for the public good of the most eroded lands, which were then grouped together in "périmètres RTM" (mountain land perimeters), and made State property.

"Exemplary work (reforestation of the upper valleys and the correction of torrent beds) was done in the Alps and the Pyrenees to protect transportation routes and valley management (irrigation, towns, industries). The problems of poor herders were "solved" by having them emigrate to industrial towns and the colonies." (Source: Roose et al. in an article written for ORSTOM, 1998 [135]).

The RTM-type techniques were based on the following:

- the building of "RTM dams" with durable materials (re-enforced concrete, rock filling), often fairly big (about from 1 to 10 metres high) in the beds of the main torrents so as to stop the digging and deepening of the bed by regressive erosion. Moreover they could hold back sediment upstream. Many torrents were thus treated by veritable "stairways" of RTM dams;
- the treatment of basic gullies that feed the torrents by small works in lighter materials (e.g. brushwood dams);
- the reforesting or revegetation of watershed slopes; generally speaking any attempt to reforest an actively eroding slope is bound to failure if regressive erosion continues to deepen the bed of the torrent running at the foot of the slope. Inversely in some cases there can be spontaneous natural reforesting of slopes once the deepening of the bed by erosion has been stopped by the RTM dams.

Because of its age, the RTM is a reference for any soil conservation policy. Since the time it was conceived and carried out in the Mediterranean mountains of France, North Africa, the Near East (Turkey, Syria and

Lebanon) and the Middle East (e.g. Iran), RTM has lost ground to the development of the concept of integrated management. Yet even if the institutional context (expropriation by the State) has changed, a number of techniques (e.g. the building of works and correction devices) related to it remain viable for stabilising the soils of torrential basins.

Soil and Water conservation

This strategy has been developed in the United States in the 1930s by agronomists. For 50 years it has relied upon an organisation revolving around a service for conserving water and soils in each district. The service advises demanding farmers, providing them with technical and financial aid for managing their lands. The activities of the field services rely on a central department where agronomists and hydrologists work. This department conducts studies of various erosion types and run-off processes and makes evaluations that are used as the bases of projects. Several Mediterranean countries have organised their soil conservation departments in this manner.

Soil defence and restoration

Soil defence and restoration (DRS) was developed in Algeria, then around the Mediterranean rim between 1940 and 1960 to counter the serious problems of sedimentation in man-made reservoirs and the degradation of roads and lands. It essentially was a matter of restoring lands degraded by over-grazing and clearing to productivity and to restore their infiltration potential. Often considerable terracing was done with enormous mechanical means and abundant local manpower. It consisted of covering slopes with bench terraces parallel to contour lines, with each terrace containing a crop row, an infiltration ditch and a earth bank and often planted with trees. The primary concern of foresters who created the DRS was to regenerate agriculture within the framework of "rural renovation". The place given to agriculture was thus totally essential in contrast to the usual practices of the RTM (Source: E. Roose et al. in an article written for ORSTOM, 1998 [135]).

4. 3. Limits to conservation strategies

The conservation strategies carried out in the past have had varying degrees of success. On the north shore of the Mediterranean, population movements from country to town alleviated a lot of the pressure that was applied to fragile lands. Along with the RTM efforts, there were the effects of spontaneous natural reforesting that generally followed abandonment of agriculture and grazing. With the result that in the North erosion is generally much less disastrous today than it was in the 19th century.

In the South such is not the case. Pressure remains extremely high, and we see the relative failures of conservation strategies applied in these countries (see Box 10).

Box 10: The relative failure of soil defence and restoration (DRS) in Algeria

In Algeria a survey carried out by the INRF-ORSTOM team with collaboration from the Eaux et Forêts showed that of 350,000 managed ha, more than 20% have disappeared and over 60% have been degraded through lack of maintenance. Concerning developments in good condition, it has not been proven that erosion posed major problems. It is always possible to think that without these imperfect developments the situation would have been worse, but the researchers observe that despite 40 years of heavy investment to impose DRS, the land continues to degrade, the reservoirs silt up rapidly (lifespan of from 30 to 50 years) and fuel wood is in scarce supply.

(Source: E. Roose et al., ORSTOM, 1998 [135])

There are many reasons for these failures. First of all there is the fact that these policies were designed within the framework of colonial rule (DRS). In the simplest of cases, the projects' lack of positive results is due to their poor technical design, i.e. the conservation methods chosen were not adapted to the soil or the climate. However all too often the conservation projects' relative failure was due to a combination of errors that, through lack of project follow-up and evaluation, were repeated from one project to another. In the majority of cases a systemic approach, which would have integrated the various natural, social and economic dimensions, was lacking, probably because of the complexity of such an approach. The following are the principle reasons given for explaining the failures.

Poor planning, careless execution or a lack of project follow-up

Conservation works are abandoned following their implementation and degrade through lack of upkeep. The consequences are serious to a greater or lesser extent depending on the type of works. Beyond the wasting of an investment "made for nothing", it happens that the degradation of the works is often the cause of greater erosion than if the works hadn't existed. To void such an outcome, conservation projects must be kept up in time through maintenance that involves local actors.

Poor involvement of local actors

Now this appropriation by local actors is often an issue. Projects have often not taken these actors into account, including them too rarely and insufficiently into the decision-making, management, maintenance and development process. The keys to a project's success are a proper accounting of social and economic situations and, even more, a genuine participation by beneficiaries.

Contradictions between conservation projects and other policies affecting soil management

Other "political" signals are sometimes in contradiction with better soil conservation, e.g. according to de Graaff et al. (W. Valk, 1997 [154]), the subsidies granted in Europe to the cultivation of olive groves encourages an extension of olive-tree cultivation onto marginal lands without encouraging farmers to apply the necessary conservation measures. If the incentives (particularly financial) of these policies are more interesting than those of conservation policies, farmers are usually quick to make a choice... to the detriment of their land.

Generally speaking short-term interests are contradictory to the objectives of soil conservation. This is especially true for small farmers who haven't many means and for whom immediate survival is the major priority. Downward pressure on farming prices (following, for example, the adoption of free-trade practices) can be an additional element in the failure of long-term conservation policies by again increasing the urgency and acuteness of the survival problems encountered by poor farmers.

Poorly defined goals

The lack of clear identification of the stakes and goals of conservation policies harms their coherence and their effectiveness. Certain works, for example, seem intended more for giving work to jobless farmers than for truly reducing soil degradation. In reality conservation projects are too often dispersed, punctual (fragmented and isolated plots) or are not executed on the proper scale and consequently have little impact on the state of overall land degradation. There is all too often a lack of co-ordination in management and conservation policies on the different levels of a country (national, watershed, sub-basin, coastal) and a bad distribution of costs and advantages between the upstream and downstream communities. Indeed downstream almost always benefits from the advantages of the conservation measures but rarely covers the costs, which in general are imposed upstream. Moreover, the soil conservation policies are too often disassociated from those of water and biodiversity conservation whereas they should always go together.

4. 4. A new approach: conservation management of water, the biomass and soil fertility (GCES)

Since from about 1975 to 1980 many criticisms have been made by researchers, socio-economists and agronomists, who, observing frequent failures in the past, have questioned the lack of taking the input of local populations into account (Lovejoy and Napier for Plan Bleu, 1996 [79]). In response to these criticisms a new strategy has been worked out that should take the needs of land users and managers (both farmers and cattle-raisers) into account. This new approach—called conservation management of water, the biomass and soil fertility (by its French acronym, GCES)—offers methods that improve both the capacity of soil infiltration, its fertility and potential yields and, in consequence, the profit margins of farmers (E. Roose for Plan Bleu, 1996 [79]). It relies on the role complementarity between State and local actors. The State remains responsible for combating disastrous erosion leading to gullying, landslides and reservoir silting, as well as safeguarding the quality of water. Local farmers become responsible for maintaining the productivity of their lands by piloting the conservation management of water, the biomass and soil fertility (E. Roose, 1994 [128]).

Implementing this approach is done in three phases, i.e. preparatory discussions between farmers, researchers and the technical departments, experimentation in the field and an overall development plan. It is at present being experimented by the FAO in various African countries. For the moment there are no documented assessments of this approach.

PART 4: SOIL DEGRADATION CAUSED BY POLLUTION

Man-made pollution sources are as old as human activity. But since the start of industrial civilisation in the middle of the 18th century, they have increased in number and extent, and the pollution phenomena have sometimes grown exponentially up till now. The following are the main soil pollution sources (EEA, 1999 [43]):

- Modern farming and the systematic use of chemical fertilisers and pesticides and the irrational development of irrigation that can lead to the accumulation in soils of strong concentrations of toxic substances;
- Industry, not just via localised pollution due to factories or mines at production but also by scattered pollution related to use and consumption of the products;
- The dumping of agricultural, industrial and household waste.

As for all problems of soil degradation, prevention is always less costly than the rehabilitation of polluted soils. Indeed pollution is sometimes irreversible or can have major delayed impact.

The data about soil pollution in the Mediterranean are rare and punctual. Those reported by the FAO (TERRASTAT database, see Map 6), show that the surface-areas concerned are relatively limited compared to those affected by erosion or anthropogenic occupation. Nonetheless a certain number of recurrent phenomena on the Mediterranean Basin level emerge from the document review. Among the kinds of soil pollution most often mentioned in the Mediterranean are salinisation and heavy metal pollution. Pollution from nitrates, phosphates and pesticides is poorly documented.

1. Salinity and alkalinity

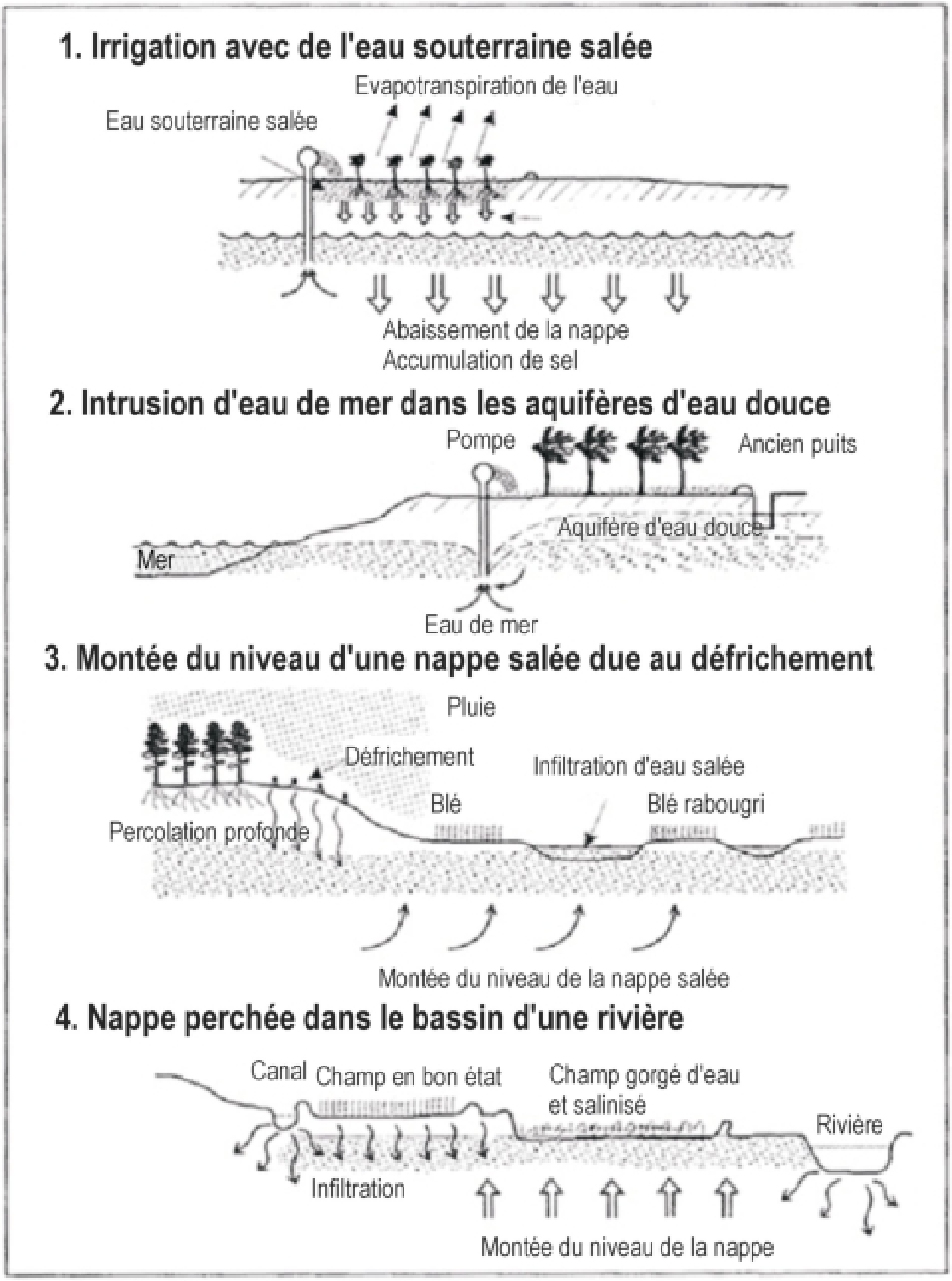
1. 1. The phenomena and their causes

There is on the one hand primary salinity, naturally created due to the proximity of the sea or the existence of geological, sometimes present-day, saline deposits, and on the other, secondary salinity due to the processes of salinisation related to anthropogenic activities, especially poorly led irrigation in certain farming areas. Naturally saline soils are frequent in arid areas because the potential evaporation of the soil greatly surpasses the quantity of water that gets to the soil. This enables salts to accumulate near the surface. Secondary salinity covers smaller surface areas than primary salinity but has greater economic consequences for it can seriously degrade the fertility of cultivated areas. The salt marshes, related to the ages-old exploitation of salt in the Mediterranean region, are an intermediate case.

The main factors responsible for the salinisation of cultivated lands are illustrated in Figure 3: the irrigation of lands with salt water; the intrusion of sea water in fresh-water aquifers (especially in coastal areas); a rise in the level of a saline watertable, even in the absence of irrigation, because of the discrepancy in the water balance, for example following land-clearance; the rise in level of saline watertable because of over-abundant irrigation or poor drainage. This latter case is unfortunately too frequent and leads to serious degradation, in the Nile Valley for example.

The presence of soluble salts in the soil has a depressive effect on plant growth after a certain threshold, which varies from one species to the next.

Figure 3: The four main modes of soil salinisation

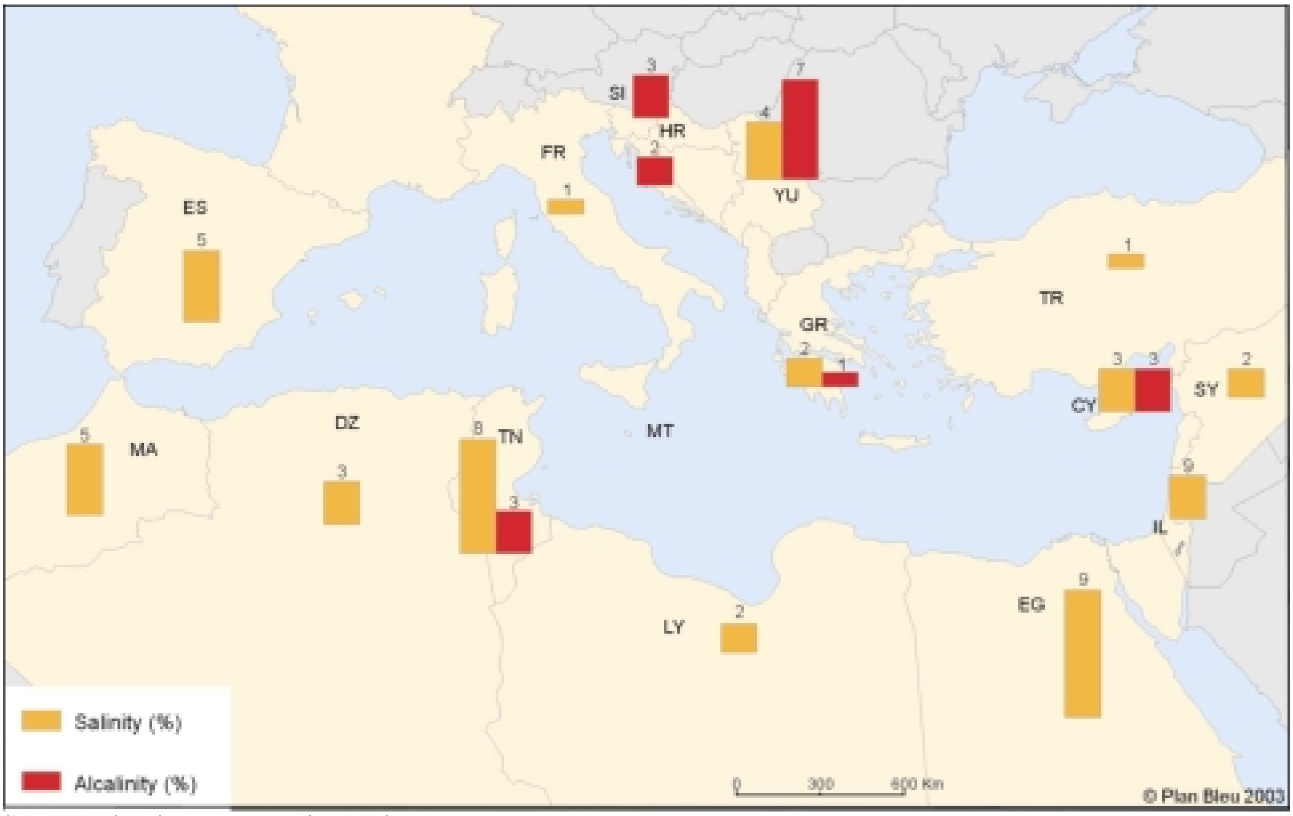


(Source: N. Middleton et al., 1997 [93])

Soil **alkalinisation** corresponds to the adsorption of sodium instead of other cations (potassium, and calcium in particular) on its clay minerals. It can lead to serious degradation of soil structure through dispersion of colloidal, clay or organic substances. An alkaline soil generally has low permeability to water and air and a high pH (surpassing 8.2), which inhibits the growth of most plants with the exception of a few species adapted to these very special conditions. Like salinity, alkalinity can be either primary and natural or secondary and induced by mankind (N. Middleton et al., 1997 [93]). It is encountered particularly on desalinated soils by the sea or, fairly recently, on farming lands that have received heavy spillage of sodium-rich farming effluents (IFEN, 1999 [71]).

1. 2. Figures for the Mediterranean

Map 6: Salinised or alkalinised surface areas in several Mediterranean countries (in % of the total national area)



(Source: map based on TERRASTAT data, 2001)

FAO data reported by the TERRASTAT database do not distinguish between naturally saline surface areas (primary salinity) and man-made salinised surface areas (secondary salinity related for example to poor irrigation management). Compared to surface areas affected by erosion, the figures are relatively low. There are data about man-made salinised surface areas in the AQUASTAT database, but the figures are available only for Albania, Cyprus, Egypt, Malta, Slovenia and Syria. In all these countries the surface areas salinised by mankind are considered nil except in Egypt: 1,210,000 ha (12,100 km^2, or 1% of the country) and Syria: 60,000 ha (600 km^2, or 0.3% of the country).

Soil alkalinity concerns very small surface areas. In all, over all the countries for which data are available, alkalinity affects less than 1 per cent of the land.

One often finds in the documents for the salinisation and alkalisation of lands in the Mediterranean countries figures that are very different from the official FAO figures cited above. The following paragraphs give the figures found in this documentation. These figures are very variable depending on the sources. The discrepancies are troubling and hard to explain. The causes cited, however, are always the methods of irrigation and drainage that are not very sustainable because poorly thought out and badly adapted to the lands to which they are applied.

According to Middleton et al. (N. Middleton et al., 1997 [93]), secondary salinity and alkalinity above all affect irrigated perimeters that they gradually sterilise, i.e. a third of the 2.5 million hectares of irrigated lands in the Mediterranean region would be affected.

In **Egypt** the shift from seasonal irrigation to permanent irrigation thanks to the building of the Aswan Dam has caused a rise in the level of the watertable and the salinity of the soil in the Nile Valley. Likewise in the Nile Delta, following an ambitious irrigation project that had been developed for cultivating the polders of Mansur and Zawia, about half the land was abandoned or couldn't be cultivated because of salinisation (N. Middleton et al., 1997 [93]). In Egypt about 35 per cent of cultivated lands suffer from salinity (EEAA, 1997 [44]). (According to the FAO, 87,000 km^2, are meant to be affected by salinisation, including naturally saline soils that cannot be cultivated because of this, which represented in all nearly 2.5 times the cultivated surface area in Egypt in 1994.)

In **North Africa** salinisation mostly affects irrigated regions and the low-lying parts subject to large evaporation rates. In these regions there is a high risk of watertable salinisation (A. Conacher et al., 1998 [30]). In **Algeria** sebkhas and chotts cover several thousand hectares in regions where less than 100 years ago the Atlas pistachio trees were still cultivated (the betoums) (Université de Nice 1992 [152]) (FAO: primary plus secondary salinity: 72,000 km^2, or 90% of the country's cultivated surface in 1994.)

In **France** salinity and alkalinity affect about 1,000 km^2 (IFEN, 1999 [71]) (2,000 km^2 according to the FAO's figures, or 1% of the country's cultivated surface area in 1994). The Camargue is a region known for its salinity; it is a primary salinity. Secondary salinisation does not affect large surface areas for the watertable is not generally mineralised (IFEN, 1999 [71]).

Salinisation in **Italy** is an important phenomenon, especially in Tuscany, Sardinia and the coastal plains (Val di Corribia, Val di Cecina, Pianura Versiliese) (Italia, Ministero dell' Ambiente, 1997 [74]). The appearance of crusting on saline soils in drought periods affects about 8,000 km^2 in Italy (A. Conacher et al., 1998 [30]) (3,000 km^2, according to the FAO, would be affected in Italy by salinisation, or 3% of the country's cultivated surface area in 1994.)

In **Greece** there are 1,500 km^2 of plains, especially near the coasts, that have salinity levels too high for them to be used in their present form without being modified (FAO: 3,000 km^2, or 9% of the country's cultivated surface area in 1994.)

In **Spain** saline soils cover a surface area of about 1,900 km^2 (A. Conacher et al., 1998 [30]) (FAO: 24,000 km^2, or 12% of the country's cultivated surface area in 1994.)

In **Israel** continuous irrigation without satisfactory drainage has caused the salinisation of about 300 ha, and the sea-water intrusion in the fresh-watertable has imperilled the soils of the coastal areas (Y. Gradus, 1996 [65]) (According to the FAO 1,000 km^2 of land in Israel were affected by salinity, or 25% of the country's cultivated surface area in 1994.)

1. 3. Specific responses

The best response to combat secondary salinisation is often well thought out irrigation where the water input, assuming it is non-salty water, does not exceed the needs of the crops. This type of irrigation is facilitated by the development of modern micro-irrigation techniques and other advanced techniques enabling regular and precise monitoring of crop water needs. Care must be taken that the irrigated lands be adapted to this practice. For example, soils with very poor drainage capacities or very fine texture should not be irrigated.

When irrigation water is slightly loaded with salts, an excess of water must be used, and an effective drainage system has to allow the water brought in with the irrigation to be carried away by the drainage out-flow. When the main risk is the rise in the level of saline watertable, contact between the saline watertable and irrigation water must be carefully avoided by draining the watertable and by limiting the input of irrigation water.

From a strictly technical point of view, it is possible to regenerate saline or alkaline soils, but these methods are generally costly:

- Certain alkaline soils can be recuperated by applying gypsum and other calcareous amendments: the calcium cation is adsorbed on the clay particles, which makes it possible to improve soil structure. The addition of organic matter complement increases the chances of success. In order to be effective, the additions must be about a tonne per hectare. Improving the soil structure is temporary with the application of amendments generally being repeated every few years (N. Middleton et al., 1997 [63]).
- Certain saline soils can be recuperated by leaching, i.e. by irrigating abundantly, then draining effectively. Excessive salt is then drained off with the escaping water. For this system to work, the soils must imperatively be well drained. It is often poor drainage that leads to soil salinity; so it is a pre-requisite than an effective drainage system exists along with an effective water-collecting and evacuation system, or that such a system can be installed. This often means a total restructuring of the irrigated perimeters, and the cost of such operations can easily exceed $1,000 per hectare (N. Middleton et al., 1997 [63]).

2. Soil acidification

2. 1. The phenomenon

There are several causes for soils becoming acid:

- The importation by agriculture of certain acidifying fertilisers;
- Dry or acid-rain deposition of pollutants (e.g. sulphur dioxide, nitrogen oxides) emitted by vehicles, boilers, thermoelectric power plants and certain industries;
- The massive planting of certain softwood trees (spruce) and certain hardwood trees (eucalyptus).

Acidification can lead to soil depletion of minerals such as magnesium, potassium and calcium or to the mutation of other minerals such as aluminium and manganese in a form toxic for plants. Downstream of acidified watersheds, streams can be acidified, and this disturbs the fauna and flora (IFEN, 1999 [711]).

2. 2. Figures for the Mediterranean

The phenomenon has not been measured much and not much seen in the Mediterranean. In **France** it has only been indicated in the east of the country (IFEN, 1999 [71]). In **Italy** the phenomenon is considered as non-existent because of an abundance of carbonated soils that make it possible to buffer acidity (Italia, Comitato Nazionale per la Lotta alla Desertificazione/Italia, Ministero dell' Ambiente, 1999 [73]). In **Greece** there are no figures available in documentation, but it has been reported that the rise in use of nitrogen-rich fertilisers has generated an increase in the acidity of certain soils (A. Conacher et al., 1998 [30]).

2. 3. The responses

By reducing the addition of acidifying inputs, well thought-out fertilisation can limit acidification and its effects but does not enable the restoration of the soil's buffer capacity. Liming can be considered for increasing the pH but can have undesirable effects on the soil's micro fauna and micro flora and accelerate the soil's humus mineralisation. In all cases liming should be managed in such a way as to increase the pH in a progressive way, preferably with slow-dissolving limestone or dolomite (D. Stanners et al., 1995 [134])

3. Pollution from pesticides, nitrates and phosphates

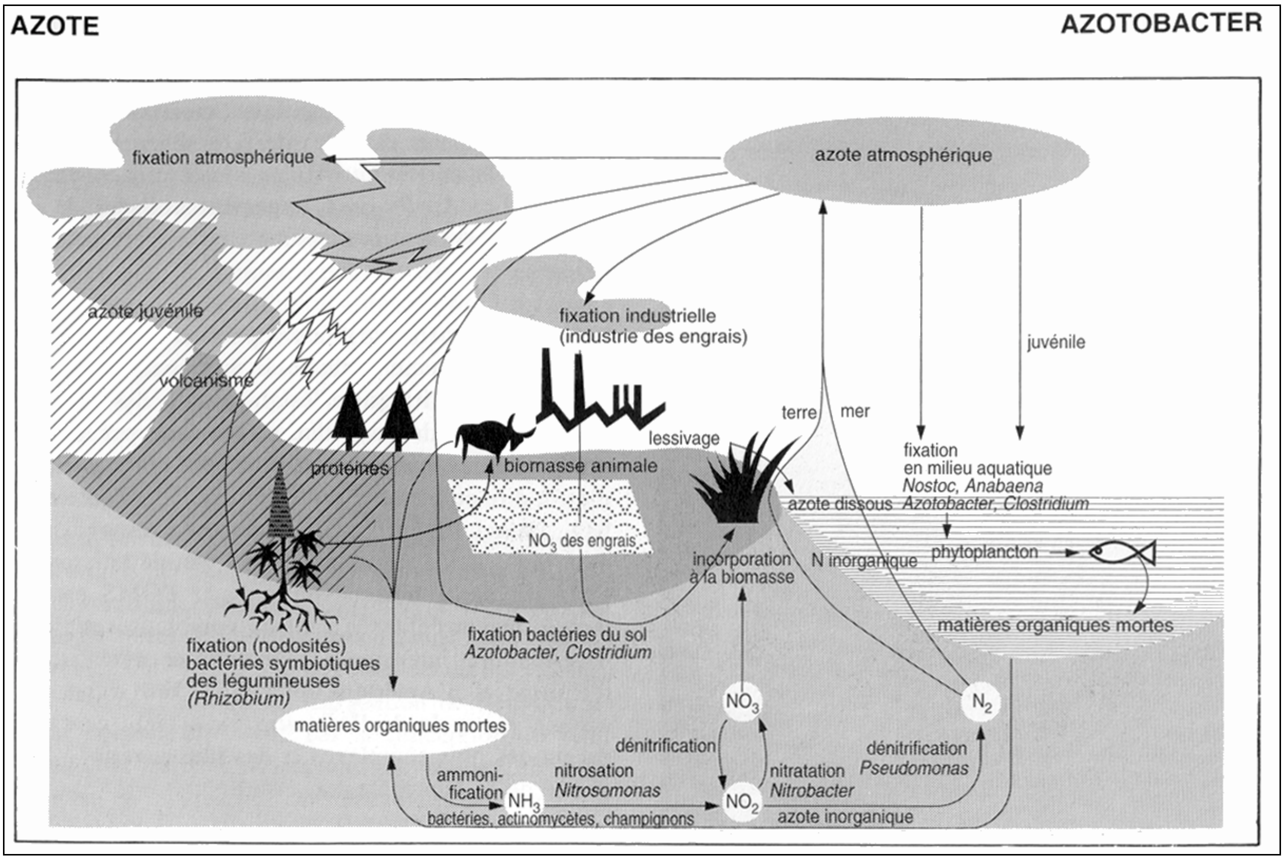
3. 1. The phenomena

Agricultural additions of pesticides, nitrates and phosphates change the soil's biochemical balances, thus their properties. The positive effects of these modifications (increase in fertility, reduction of diseases) are obviously the effects aimed at by farmers. But there can also be negative effects, which, with excessive application can become genuine pollution. This pollution can be apparent on-site or downstream, off-site, with transport of the products. Generally speaking, nitrates are transported as dissolved salts by run-off or infiltration water. Phosphates and pesticides are transported as molecules or crystals bonded to soil particles carried off by erosion.

Nitrates heavily modify the nitrogen cycle (see Figure 4), especially the C/N ratio, the degree of decomposition of organic matter and then the structure of soils and their water storage capacity. In cases of poorly managed fertilisation there can be local soil degradation (e.g. acidification, slaking crust). Water-carried nitrates pollute streams and ground water. They can cause more or less serious eutrophication of rivers, standing water and coastal areas, leading to degradation of biodiversity, fishery resources and the landscape. They are the cause of additional costs in water treatment (EEA, 1999 [43]) and can even make water unclean for consumption.

Phosphates are also a major cause of eutrophication. Once erosion has deposited phosphor-rich sediment at the bottom of natural or man-made standing water, it is very hard to eliminate it. Phosphates are veritably trapped in these sediments, which then constitute a permanent threat of eutrophication by graining out.

Figure 4: The nitrogen cycle



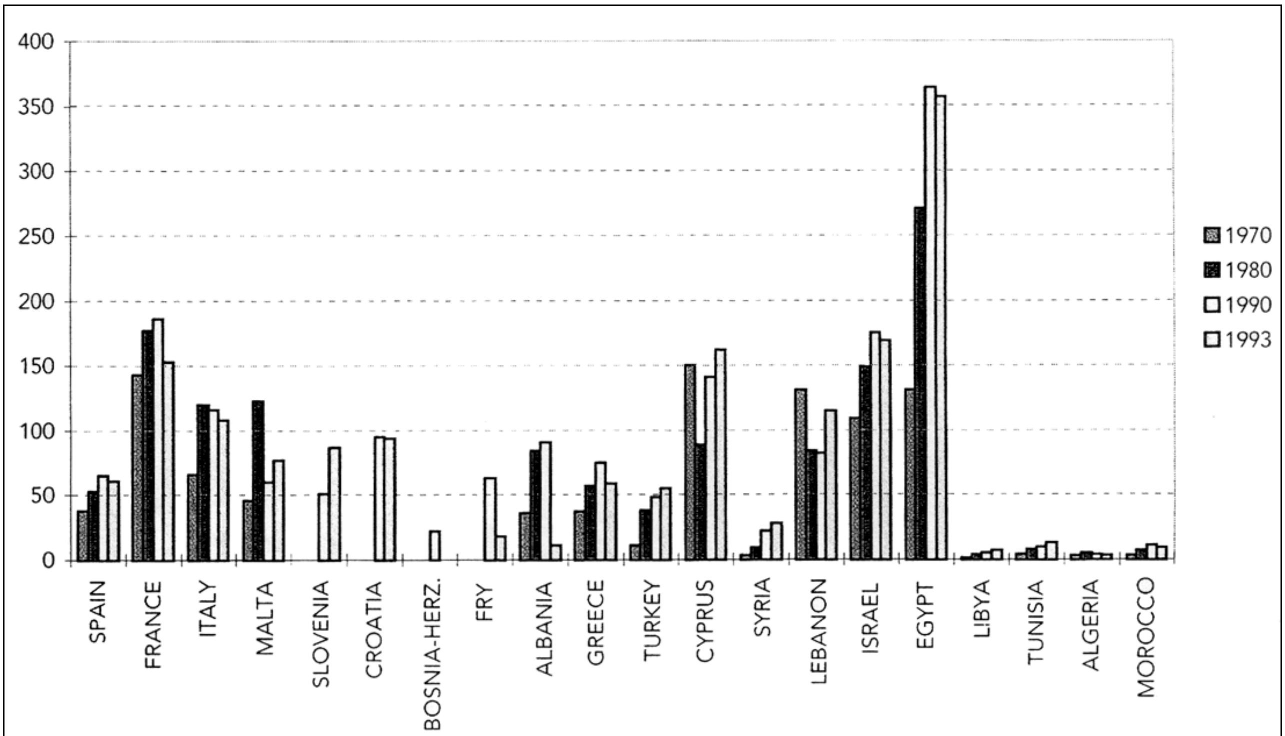
(Source: F. Ramade, 1993 [125])

Pesticide pollution can lead to polluting surface water and watertables through run-off. Serious danger to human health can be the consequence. The picking up of active matter depends on the soil structure, its capacity to absorb them and the abundance of rain that follows the treatment (rain occurring just after treatment can leach 20%, even 30%, of the applied amount). The picking up of pesticides at depth is less intense but more continuous (about 1% of the application). This is sometimes enough to make aquifer water unclean for human consumption.

3. 2. Figures for the Mediterranean

Figure 5 shows the evolution of fertiliser consumption in the Mediterranean countries. It appears that the eastern Mediterranean countries (Lebanon, Israel and Egypt) are the biggest consumers of fertilisers. It can reasonably be supposed that the problems of pollution and eutrophication are consequently also higher.

Figure 5: Fertiliser consumption in the Mediterranean countries from 1970 to 1993



(Source: EEA, 1999 [43])

In France and Morocco it is estimated that between 8 and 10 per cent of the nitrogen incorporated into the soil is not used by plants (IFEN, 1999 [71] and Morocco, Ministry of the Interior, 1993 [90]). In Spain using excessive amounts of fertilisers in very intensively irrigated market garden crops causes serious problems.

3. 3. Responses

The best way to fight fertiliser- and pesticide-caused soil pollution is by applying these products in a reasonable way and not exceeding the plant needs.

Ways of reducing pesticide pollution (D. Stanners et al., 1995 [134]):

- Obeying the amounts to be applied (limit excess);
- Integrated control (biological) of harmful organisms;
- Selecting crops resistant to harmful organisms;
- Purifying active ingredients that make it possible to reduce amounts to be applied;
- Banning persistent and very mobile pesticides;
- Banning of wide-spectrum use pesticides (also having impact on organisms other than the targets);
- Improving application techniques (also making it possible to reduce amounts);

– Developing biotechnologies.

Ways of reducing pollution from nitrates and phosphates (D. Stanners et al., 1995 [134])

– Selecting plants less demanding in nutrients;
– Applying fertilisers at the right periods to increase effectiveness;
– Improving application methods;
– A more exact evaluation of fertiliser quantities to apply according to plant needs and the nitrogen quantities in the soil (with more precise evaluation of nitrogen concentrations with modern methods);
– Minimising losses through leaching by integrating catch crops enabling nitrogen fixation in winter;
– Reducing the animal load in highly intensive cattle-raising regions.

4. Heavy metal contamination

4. 1. The phenomenon

Soils naturally contain a lot of chemical elements, in particular metals. Some of them have no notable biological effects. Others (copper, for example) in mild doses constitute micro-nutrients that are indispensable for plant development but are toxic in higher concentrations and can become and a threat to the food chain and to human health. Others still (e.g. mercury) are always toxic. Heavy metal concentrations in soils can vary a lot. High heavy metal concentrations can be either natural (due to geological substrates for example) or man-induced, due to direct or indirect input related to human activities (EEA, 1999 [43]). The most frequent causes are the spreading of phosphate fertilisers (cadmium), pork slurry (copper and zinc) or purification plant sludge; industrial pollution; and car-traffic related pollution (lead). Man-made heavy metal input is often present in a more highly reactive form and thus more dangerous than naturally occurring minerals.

The most dangerous elements for mankind and animals are mercury (Hg), lead (Pb), cadmium (Cd) and arsenic (As). Copper (Cu), nickel (Ni) and cobalt (Co) are only dangerous in high concentrations. The toxic levels of these elements depend on their concentration (critical thresholds are different from one element to another), their chemical form, soil characteristics (buffer capacity), plant cover and the climate, all of which condition the biochemical processes of metal evolution in the soil (trapping in insoluble form or, the contrary, releasing into the environment) (EEA, 1999 [43]).

4. 2. Figures for the Mediterranean

The lack of a common framework for defining and monitoring contaminated sites makes it impossible to compare the various Mediterranean-rim countries. In southern **France** numerous viticultural and arboricultural areas have been contaminated for a long time by the copper from what is known as the "bouillie bordelaise", Bordeaux mixture. Intensively farmed plots can be contaminated by metals related to plant-protection products (Zn, Hg, Pb, Cu and As) or fertilisers (Cd) (IFEN, 1999 [71]). In south-western **Sardinia**, the largest mining complex in the Mediterranean Basin injects lead, zinc, chromium and cadmium into the soil as well as in to the water of watertables, lakes, lagoons and in the sea. In **Europe,** and even more so in the entire Mediterranean Basin, important sources of contamination are constituted by badly controlled dumps receiving toxic waste, the poor recycling of certain industrial waste and the abandonment of industrial, mining and military infrastructures.

4. 3. Responses

The reduction of heavy metal emissions is the best way to reduce the accumulation of these elements in the soil. The use of lead-free petrol in the European countries has made it possible to reduce lead emissions into the atmosphere despite the large increase in the automobile fleet.

For farming lands heavy metal input into the soil can be reduced by (D. Stanners et al., 1995 [134]):

- Using low concentrations of heavy metals in fertilisers and reasoned fertilisation;
- Using animal food additives less frequently and by reducing their heavy metal content (e.g. avoiding the addition of Cu to improve food assimilation);
- Replacing inorganic pesticides (e.g. "bouillie bordelaise") with biodegradable organic products.

The restoration costs of soils polluted by heavy metals are almost always extremely high. The techniques used range from excavating the soil and eliminating the waste off-site to covering ground with an impermeable material to avoid contact with water and reducing the risks of pollutant leaching towards watertables. Purifying water most often means pumping and treating it. More advanced technologies such as treating contaminated sites on-site are not very widely spread because of their low success rate.

Certain countries catalogue polluted sites, e.g. France where the ADEME agency lists polluted sites and Italy where the authorities have identified sites to be rehabilitated. But rehabilitation is so costly that for the moment few of these sites have been cleaned up.

Because of treatment costs, preventative measures are recommended in all cases.

PART 5: INSTITUTIONAL PROVISIONS (AND THEIR INSUFFICIENCIES) FOR PROTECTING SOILS

1. Raising awareness for the need to protect soils

The **Soils Charter** adopted by the Commission of Ministers of the **Council of Europe** at the 1972 Stockholm Conference was a first step in recognising the fragile and limited nature of soils on an international level and of the need to protect them. It made official the idea that the environment and the management of natural resources must be seen in a systemic way by integrating the direct and indirect causes of their deterioration (pollution and excessive exploitation of natural resources) and not just in a purely analytical way as was usually done up till then.

On a global scale, the **International Soils Charter**, worked out in **1981**, sets out the definition of a set of reference principles with a view to a more rational use of soil resources and their protection against irreversible degradation. It recommends that decisions about land use and management be done in a long-term perspective and stresses the need for States to work out policies and legislation ensuring the protection so vital to soils.

Yet the major awareness raising on an international scale for the need to manage the environment in general and the soils in particular in a sustainable way occurred at the United Nations Conference on the environment and development, known as the **Rio Summit**, in **1992**. It highlighted the importance of an ecologically viable management of soil resources within the framework of sustainable development by accounting for the links between the economy and the environment on a global and long-term basis. Some of the themes considered during the Conference affecting soil conservation were desertification, farming impact, deforestation and soil use. The Conference gave rise to a detailed orientation document called "Agenda 21" that reiterated environmental and developmental goals and suggested a large range of private and public initiatives for achieving them in the 21st century.

2. International actions

2. 1. The Agenda 21 and Med Agenda 21 plans

The "Agenda 21" plan, adopted and signed at the Rio Conference, contains seven sections, each about the desired future for the planet. Soil management is discussed in the section for a fertile world, including measures meant to ensure the efficient use of natural resources by rationalising systems of production.

In November, 1994, a certain number of environmental ministers from Mediterranean-rim countries took part in Tunis on the Med 21 theme within the framework of the Mediterranean Action Plan (MAP), focusing on sustainable development in the Mediterranean Basin. The outcome of this conference was the writing of the **"Agenda MED 21"** plan, the Mediterranean version of Agenda 21.

2. 2. The UNCCD and plans for combating desertification[3]

The first United Nations Conference on Desertification (UNCD) was held in **Nairobi in 1977**. It launched the first call against desertification and adopted an Action Plan for combating desertification.

[3] According to the UNCCD's official definition, "the term "desertification" designates the degradation of lands in arid, semi-arid and dry sub-humid areas, following on various factors, among which are climatic variations and human activity; the expression "combating desertification" designates the activities derived from the integrated enhancing of lands in arid, semi-arid and dry sub-humid areas with a view to sustainable development (article 1 of the CCD).

At the 1992 Rio conference the subject of desertification was treated as an important problem that had to be dealt with urgently. The CCD extended its know-how to all countries affected by desertification, including Mediterranean Europe. It called for a new integrated approach to the problem, essentially aiming to highlight the relationships between economic development and environmental protection while fully including the populations and civil society so as to make the combat programmes more effective.

The **United Nations Convention for Combating Desertification (UNCCD)** is an international legal instrument for engaging all signatory countries to co-operate in the fight against desertification. It came into force in **1996**. To date 175 countries have signed it. They are divided up into four geographical zones: Africa (Annex I of the Convention), Asia (Annex II), Latin America and the Caribbean (Annex III) and the northern shore of the Mediterranean (Annex IV). The Mediterranean Basin is therefore shared between annexes I and IV.

To structure policies, the UNEP asked countries to establish National Action Programmes that would set out long-term strategies, specify measures to take and attack the underlying causes of desertification.

2. 3. Programmes for the Mediterranean Basin

MAP and MCSD: a cross-sectional approach to soil degradation

The Mediterranean Action Plan (MAP) was founded in 1975 under the aegis of the UNEP. The results of its work, in particular that carried out by Plan Bleu (which is one of the MAP's regional activity centres) were constituent elements that led in 1994 in Tunis to the elaboration of the Agenda MED 21 programme as well as the decision taken in 1996 in Montpellier to implement a Mediterranean Commission for Sustainable Development (MCSD). The MAP was itself successfully revised in Barcelona in 1995 (MAP II). Since 1995 the MAP has put the combat against erosion and desertification among the main objectives for sustainable development in the region.

The EUROMED partnership and soil management

Relationships between the northern Mediterranean countries and those of the South and East were until 1995 only carried out within the framework of bilateral agreements. Association Agreements progressively replaced these agreements within the context of the Euro-Mediterranean Partnership (EMP), which was established at the Euro-Mediterranean Conference in Barcelona in 1995[4].

The MEDA programme is the main financial tool in this partnership. The Short and Medium-Term Priority Environmental Action Programme (SMAP) is the environmental component of the EMP. It enables joint actions on a Mediterranean-wide level and supplies orientations for policies and funding, the goal of which is to ensure synergies with other existing programmes and instruments. One of the SMAP's five priority fields of action concerns the desertification issue.

NGOs

A number of regional programmes have also been launched in co-operation with other multilateral bodies and international Non Governmental Organisations (NGOs) active in the region. In particular there is the Sahara and Sahel Observatory, founded in 1992 with the vocation of working within the framework of implementing the CCD and Agenda 21 in Africa. Its main objective is to promote the development and enhancement of its partners' informational capital with a view to optimum use of the means for combating desertification.

[4] The 27 Euro-Mediterranean partners are the 15 members of the EU and the Mediterranean countries: Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, the Palestinian Authority, Tunisia and Turkey.

Networks enable NGOs to co-ordinate their activities and share their experiences in fields that concern them, e.g. Mediterranean networks such as MEDFORUM[5], which in September of 2001 brought together 115 organisations from 23 countries, and the Mediterranean Information Organisation.

2. 4. A mitigated balance sheet of international action, the UNCCD example

The main criticisms of the UNCCD first of all concern the weakness of the Convention's scientific dossier. Indeed whereas scientific programmes for the arid areas had already started by the end of the 1960s, the responses offered by scientists on the questions of soil degradation were still disputed and divergent, even contradictory in many cases. Disagreements occurred over the phenomenon's definitions, the mechanisms involved, the magnitude of its evolution and the combat strategies to promote. In 1991 the UNEP concluded that the issue of soil degradation in arid, semi-arid and dry sub-humid areas had got worse.

Moreover there was reticence to fund National Action Plans for combating desertification. This was due to the weakness of the Convention's scientific dossier and to a certain tendency to over-dramatise the risks of desertification without providing for real action means when it meant setting priority objectives in the fight. Moreover the work asked of the countries for writing their National Action Plans was too big. In the Mediterranean Basin efforts led only to proposals that some people thought too dispersed, unrealistic and devoid of financial evaluation with the notable exception of Tunisia. It would seem that one deep-seated reason originated in geographical and political diversity that made choosing an acceptable common strategy difficult within the CCD. (P. Rognon, 2001 [127]).

It would seem that most of the funds earmarked for combating desertification were absorbed by institutions, NGOs and meetings about desertification, leaving only small amounts for action programmes and projects or for real, long-term research on desertification. In all, less than 10 per cent of the money spent appears to have gone to real combat projects or long-term research. Developmental aid is in crisis. The goals set at the Rio Conference were to be 0.7 per cent of GDP. In practice France allocated 0.38 per cent in 1999, and the United States 0.1 per cent.

Despite such criticism, combating desertification is more than ever considered a major challenge leading to the recommendation formulated at the Johannesburg sustainable development summit to consider designating soil degradation (desertification and deforestation) as a sphere of intervention for the Global Environment Facility so as to enable the latter to promote the effective application of the United National Convention on Combating Desertification.

3. National action

National programmes are too numerous to make an exhaustive presentation here. But it is worth noting that in practically all countries numerous authors level serious and convergent criticism at them stating that too often environmental issues, in particular those concerning soils, are not systematically included in the formulation of governmental policies.

In most Mediterranean countries the allocation of responsibilities about using the soil resource is dispersed among several bodies that act on different geographical levels. The lack of coherence and co-ordination between sectoral policies, the lack of information about soil management and the imbalance between the different pressure groups (urban, agricultural, environmental) limit the effectiveness of action by public authorities and generate contradictions, even conflicts, that weaken those conservation policies adopted.

3. 1. Contradictions between sectoral policies

There are frequent contradictions between the concrete modalities of action with a view to improving farming productivity on the one hand, and the goals advertised for combating soil degradation on the other.

[5] A Mediterranean NGO network for Ecology and Sustainable Development

For example in the **Mediterranean countries of the EU** subsidies for olive production were proportional to the quantities produced a few years ago. They thus went against soil conservation in marginal areas, for they encouraged producers to intensify their production on plots of land where intensification was not adapted. This mechanism was reformed and replaced by a system of proportional subsidies to the number of trees. This new system has not solved the problem because it incites growers to clear and plant on land with very low production potential in order to receive more subsidies. Neither the old nor the new systems promote consideration for environmental or soil conservation factors (De Graaff, 1996 [64]).

An **OECD** report (OECD, 1994 [99]) shows that in numerous countries, e.g. **Turkey**, the various kinds of degradation are most often analysed and treated independently of each other and that conservation measures are as numerous and dispersed as the incriminated factors whereas in fact the various degradation phenomena are interacting, even intertwining, and that measures should be integrated.

3. 2. Poor co-ordination between organisms

An overly complicated and confusing system on the institutional level with poor vertical integration can result in the non-treatment of basic problems concerning natural resources.

In **Turkey** there is no structural co-ordination between the very numerous institutions that share the soil conservation missions. Thus on the central level according to (Orhan Dogan – PAP-RAC, 2000 [145]), "There is no soil conservation bureau, and on the regional and departmental levels the soil conservation executive (abolished in 1984) should be re-instituted to develop and pursue work on soil resources, inventories, studies, mapping, erosion control, irrigation, drainage, land re-organisation and grassroots research that at present are not correctly seen to."

Likewise in **Morocco** there are co-ordination and arbitrage problems between the institutions in charge of land management. The delimitation of responsibilities between the various actors has not been defined clearly enough. According to Laouina (Laouina – PAP-RAC, 2000 [145]), the Ministry of the Interior retains jurisdiction on local communities while the execution of hydraulic works falls to the Ministry of Town and Country Planning. The forest management agency, in charge of soil conservation and watershed planning, receives little support from local authorities and the justice department, and municipalities are often at loggerheads with the traditional "Jma'a". In addition to this complicated institutional armada there are co-ordinating institutions such as the Higher Council of Water and Climate and the National Forestry Council that emit recommendations. The facilities for beneficiary representation are not truly operational (problems of formation and funding). On the other hand the association movement is in full expansion, encouraged by donors, but there are problems of the ability to play an intermediary and anchoring role in local areas.

In **Tunisia** there is a great multiplicity of decision-making centres and actors in the same local areas. The numerous sectoral legal documents are hard to co-ordinate and implement, which may be at the origin of non-integrated sectoral projects and programmes, even on the watershed level.

3. 3. Poor integration of the different geographical levels

In **Morocco** other than the poor co-ordination between institutions, the fact that public action should above all be oriented towards large-scale operations and has not acquired enough flexible operational capacity on the small scale constitutes an impediment to the proper execution of conservation policies (PAP-RAC, 2000 [145]).

The countries examined by the OECD, including Turkey and the Mediterranean countries of Europe, are turning to greater decentralisation and an accrued devolution of decision-making in soil conservation matters (OCDE, 1994 [99]). For example in **Italy** the creation of Basin agencies should improve the ties between the local (provinces), national (ministries) and International (Agenda 21) levels.

3. 4. The lack of adapted legislation

The various countries are not all at the same point in elaborating legal frameworks for integrated soil management. In the majority of Mediterranean countries the determination to fill out and better co-ordinate legislation on soils by relying on a dynamic examination and reform process is insufficient.

The EEA has analysed European soil management, which is one of the avowed priorities in the 5th Environmental Action Programme (5EAP). It emerges that in contrast to the air and water programmes, soil protection is not the subject of specific policies. There is no legislation directly about it (primary protection), but it is touched on indirectly via sectoral measures protecting water and air (secondary protection), included, for example, in the directive on nitrates or the directive on purification plant sludge. The EEA concludes that on a European level, in the member and candidate countries there is no policy acknowledging the role played by the soils, or that takes the problems issuing from competition between their different uses into account or that aims at maintaining their multiple functions. Such policies would promote considerable improvement in the environment in Europe.

In some countries the creation of specific legislation for protecting soil resources would throw existing land laws into question, laws which if not reviewed would impede the meeting of conservation goals. For example in **Turkey**, existing laws favour the splitting up of farming concerns when they are part of inheritances, which harms the elaboration of integrated policies. In fact they often lead to the over-exploitation of grazing land by not encouraging their users to viable resource management and reconciling individual interests with collective interests on the local, regional or national levels (OCDE, 1994 [99]).

Up to 1995 in **Tunisia** the process adopted in combating erosion was not global and relied on disparate legal bases. It was founded on the provisions of the Forestry code (1966 and reworked in 1988), the Water Code (1975), the law on protecting farming lands and numerous decrees relating to certain farming techniques applied according to need. It was only in 1995, when the SWC code (Soil and Water Conservation) was implemented, that an integrated and participatory approach was instituted, based on the partnership between the administration and the beneficiaries of the works (Ali M'hiri, PAP-RAC, 2000 [145]).

3. 5. The weakness of the means of action[6]

The problems of implementing regulations can be the source of sustainable difficulties and the chronic deterioration of resources.

In **Morocco**, for example, forestry legislation is old and offers the means of action for conservation objectives since it enables the definition of exclusive users for each forest growing stock and to regulate logging by penalising unauthorised cutting. But in reality these principles are not always applied, and users, whether they have legal access or not, often practise unauthorised cuts, especially if there is commercial gain to be had (coal or wood supplies for towns). Until recently there were too many projects carried out without really involving civil society (lack of awareness); supervision remained insufficient, and the strategy of populations was often contradictory to that of the projects. The result was a lack of maintenance, even of destruction, of conservation works. Concerning protection of the forest cover, officially speaking incentive measures were rare whereas repressive measures abounded without offering users alternatives, while in practice they were not often applied, especially concerning penalising unauthorised commercial cuts (PAP-RAC, 2000 [145]). But for a while now the situation has been rapidly evolving, and Morocco has implemented exemplary integrated development projects such as GEFRIF for the participatory protection and management of the forest ecosystems of the Rif (J. de Montgolfier, 2002 [94]).

The OECD feels that in certain of its member countries (Mediterranean or otherwise) the diversity and effectiveness of the means presently employed are generally insufficient for meeting the ambitious objectives

[6] The phrase "means of action" refers to the various instruments enabling the application of legislation. They include regulatory instruments, economic instruments and public awareness (99).

of protecting and restoring the environment and that the public budget devoted to the raising of public awareness should be increased (OECD, 1994 [99]).

FOOD FOR THOUGHT FOR THE FUTURE

The analytical elements on the roles played by the soils and the diagnoses of the threats of degradation that affect them are usually the subject of consensus among countries and international organisms. In the Mediterranean region the importance of soil conservation for protecting water and biodiversity resources and for farming has been long recognised, as have the links between soil degradation and poverty.

Starting from this diagnosis, nearly everyone agrees on the fact that soil management ought to be conducted in an "integrated" way in space and time. In order to account for the social and economic context that conditions soil management, it is advisable to involve local actors as much as possible in the formulation of policy objectives, then in the execution and maintenance of the works undertaken. The decision-making processes and application should be flexible according to site specificity, local actors and the implementation of soil-conservation-related measures be delegated to the people concerned as much as possible (the "bottom-up" approach).

These principles can be considered as granted by the majority of actors involved in soil management, at least since 1992. Whereas in fact this much vaunted integration is still waiting to occur. Generally speaking even if a growing awareness of the issue is observable, there is some kind of inertia in the institutional apparatuses faced with the speed of irreversible degradation to a resource that is so precious for future economic development. All too often still, different institutions manage the various natural resources. In the allocation of priorities the soils have for long been the “poor relatives” of the environment. Despite several international agreements and the urgent nature of the degradation problems, soil conservation policies are slow to be implemented. Moreover the general public is little or badly informed of these problems, especially about the loss of fertile lands for the benefit, for example, of urbanisation. While deforestation is in the minds of and mobilises many actors - including public opinion - the awareness of the importance and impact of disappearing farming potential from construction (man-made impact) is less so. In consequence the pressure for implementing measures for limiting the irreversible disappearance of this highly productive resource are lacking. One cause of this state of things should perhaps be sought in the problem's complexity and the institutional devices required by the fight, as well as the lack of objectivity and assessments.

Practical improvement of the integrated management of natural resources would require important changes in approaches and actions, which should rely on more coherent and effective legal and institutional structures. In particular the roles of the various authorities should be better defined, and co-ordination better provided for between administrative units on the same level (e.g. between the ministries in charge of regional development, national planning, agriculture, the environment and forestry). What is certainly desirable is a decentralisation of actions leading to a more finely-tuned adaptation to on-site realities and a genuine participation of all social actors concerned. Successful water and soil conservation measures can occur only if the obstacles to long-term investment are lifted. Without land and financial security how can those farmers involved commit to long-term activities for maintaining fertile soils? This should also solicit a greater integration of environmental policies (forests, water, soils, biodiversity) and farming and rural development.

Under these conditions what we might see would be the emergence of "sustainable development engineering". It would use the analysis of strategies and actor behaviour, tools for operational action and the impact of human activity. It would seek to facilitate rational policy choices and realisable models. It would amalgamate local knowledge and practices and facilitate the emergence of compromises between actors. It would rely on the following: the integration of the local level in decision-making; mechanisms of financial, fiscal and land solidarity between resource users both upstream and down; and public aid systems modulated according to social, economic and environmental requirements. Its founding principle would be to base safeguarding the long-term (resource conservation) on improving the short-term socio-economic situation (combating poverty, consolidating income) and on establishing the conditions required for responsible and sustainable management (improving land and financial security). It would ask therefore that development and the environment not be dissociated, on the contrary, that they be fully integrated in economic action.

In order to move this real expertise on sustainable development forward, it is essential to increase after-the-fact evaluations of experiences that have seen the light of day in the Mediterranean and to encourage exchanges on this subject. Indeed, despite a rather sombre overview, there are on the Mediterranean Basin level a certain number of sustainable and integrated management experiences—though often punctual and hard to extrapolate—with exemplary value. It would be worthwhile in all countries to identify and analyse cases of the integrated management of water, agriculture, forests and soils, not to mention that the analysis of certain partial and even outright failures can constitute experience feedback that is rich in lessons. In this there is an important sphere of co-operation between Mediterranean countries to be developed.

BIBLIOGRAPHY

1. *Academia Europea per l'Ambiente-International Conference "Environmental and Sanitary Problems of Air, Land and Coastal Waters in the Mediterranean Area", Naples, Italie, 8-10 octobre 1992-Naples (ITA)-1992-217 p.*
2. *AEE/ UNEP - Etat et pressions du milieu marin et littoral méditerranéen. Résumé-Copenhague-AEE-1999-43 p.*
3. *Agropolis / ADEME - Séminaire international "Agriculture et développement durable en Méditerranée", Montpellier (FRA), 10-12 mars 1997-Montpellier (FRA)-1997*
4. *AKESBI Najib, GARCIA-ALVAREZ-COQUE José-Maria - Globalisation, natural resources and agricultural policies in the Mediterranean region-MEDIT, n°2 -Bologna-Edagricole-2001-pp. 2-12*
5. *AXIAK, Victor/ GAUCI, Vince/ MALLIA, Adrian/ MALLIA, Edward/ SCHEMBRI, Patrick J. VELLA, Alfred J.-Malta. Environment Protection Department-State of the environment: summary report for Malta 1998-1999-130 p.*
6. *BALABANIS, P. (ed.)/ PETER, D. (ed.)/ GHAZI, A. (ed.)/ TSOGAS, M. (ed.)-EC. DG Research-Mediterranean desertification: research results and policy implications-Vol. 1: Plenary session: Keynote speakers-Vol. 2: Summary of project results-2 vol.-Proceedings of the International conference, 29/10-01/11/96, Crete, Greece-Luxembourg-Office for Official Publications of the European Communities-1999/ 2000-429 p.; 615 p.*
7. *BALDACCHINO, Alfred E. (ed.)/ TANTI, Christine M. (ed.)-Proceedings of seminar-National awareness seminar on desertification and land degradation, Malta, 3-4 June 1998-Valetta-Ministry of Foreign Affairs; Environment Protection Department-1999-112 p.*
8. *Banque Mondiale EMTEN/EMENA - Les problèmes de l'environnement en Algérie. Version provisoire-Washington D.C.- Banque Mondiale-1989-76 p.*
9. *BARAKAT, Hala N. (ed.)/ HEGAZY, Ahmad K./ TOLBA, Mostafa (préf.)-UNESCO/ IDRC (International Development Research Centre)/ Egypt. South Valley University-Reviews in ecology: desert conservation and development-Cairo-1997-331 p.*
10. *BARNIER, Michel (préf.)- France. Ministère de l'Environnement- La protection de l'environnement méditerranéen. Contribution de la France - Paris- Documentation française-1994-345 p.*
11. *BARRERE, Martine (dir.) - Terre patrimoine commun. La science au service de l'environnement et du développement- Paris- La Découverte-1992-196 p.*
12. *BARTH, H. (ed.)/ L'HERMITE, P. (ed.)-CEC (Commission of the European Communities)-Scientific basis for soil protection in the European Community. Proceedings of the Symposium on Soil Protection, Berlin, 6-8 October 1986-London-Elsevier Applied Science-1987-630 p.*
13. *BERRIANE, Mohamed (dir.)/ LAOUINA, Abdellah (dir.)- Aménagement littoral et évolution des côtes. L'environnement des côtes marocaines en péril. Actes-Symposium "Aménagement côtier et évolution des littoraux dans les pays en développement" organisé par le Comité National de Géographie du Maroc et la Commission de l'Environnement Côtier de l'Union Géographique Internationale. Tétouan, Tanger et Rabat, 27 avril- 3 mai 1992-Rabat-Comité National de Géographie du Maroc-1993-119 p.*
14. *BETHEMONT, Jacques-Géographie de la Méditerranée-Paris-Armand Colin-2000-313 p.*
15. *BLAIKIE, Piers-The political economy of soil erosion in developing countries-London-Longman-1985-188 p.*
16. *BOUGEANT Pierre-La Méditerranée sur la liste rouge-Etudes foncières, n°91, mai-juin 2001-Paris-ADEF-2001-pp. 21-23*
17. *BRANDT, C. Jane (ed.)/ THORNES, John B. (ed.)-Mediterranean desertification and land use-Chichester (GBR)-Wiley-1996-554 p.*
18. *BRAUDEL, Fernand-La Méditerranée – L'espace et l'histoire-Manchecourt-Flammarion-1985-223 p.*
19. *CANGIR Cemil, KAPUR Salim, BOYRAZ, Duygu, AKCA Erjam, ESWARAN Hari-An assessment of land resource consumption in relation to land degradation in Turkey-Journal of Soil and Water Conservation, Third Quarter 2000-2000-pp. 253-259*
20. *CARSIN, Jean-Louis/ CHASSARD-BOUCHAUD, Colette-L'environnement de la Méditerranée-Paris-Puf-Que-sais-je ? n°3306-1998*
21. *CCE (Commission des Communautés Européennes)-L'état de l'environnement dans la Communauté Européenne. Aperçu-Bruxelles-CEE-1992-95 p.*
22. *CE. Eurostat. Groupe de travail "Statistiques de l'Utilisation des Sols"-Manuel des concepts relatifs aux systèmes d'information sur l'occupation et l'utilisation des sols. Document de travail-Luxembourg-2000-96 p.; 92 p.*
23. *CFCE (Centre Français du Commerce Extérieur)/ Poste d'Expansion Economique. Madrid-Espagne. La décontamination des sols-Madrid-1994-13 p.*
24. *CHALINE Claude-PNUE/PAM/PlanBleu, CMDD (Commission Méditerranéenne du Développement Durable)-L'urbanisation et la gestion des villes dans les pays méditerranéens: évaluation et perspectives d'un développement urbain durable. Document préparé pour la Réunion méditerranéenne "Gestion des villes et développement durable", Barcelone, 3-5 septembre 2001-Sophia Antipolis-Plan Bleu-2001-42 p.*

25. *CHEROT, Jean-Yves (dir.)/ ROUX, André (dir.)/ MANOS, Aldo (préf.)-Université d'Aix-Marseille III. CERIC (Centre d'Etudes et de Recherches Internationales et Communautaires)-Droit méditerranéen de l'environnement-Paris-Economica-1988-191 p.*
26. *CIHEAM. Institut Agronomique Méditerranéen de Zaragozza/ CCE. DG I (Relations extérieures)-Etat de l'Agriculture en Méditerranée. Les sols dans la région méditerranéenne: utilisation, gestion et perspectives d'évolution-Cahiers Options Méditerranéennes, vol. 1, n° 2-Zaragoza (ESP)-Institut Agronomique Méditerranéen de Zaragoza-1993-269 p.*
27. *COMBY, Joseph/ RENARD, Vincent-Les politiques foncières-Paris-PUF-1996-126 p.*
28. *Commission Européenne. DG relations extérieurs-Partenariat euro-méditerranéen. Le programme MEDA-Bruxelles-Commission Européenne-1999-22 p.*
29. *Commission Européenne. DG relations extérieurs-Partenariat euro-méditerranéen. Programme d'Actions Prioritaires à Court et Moyen Termes pour l'Environnement (SMAP)-Bruxelles-Commission Européenne-1999-24 p.*
30. *CONACHER, Arthur J. (ed.) / SALA, Maria (ed.)-Land degradation in Mediterranean environments of the world: Nature and extent, causes and solutions-New York-Wiley-1998-491 p.*
31. *COUDE-GAUSSEN, Geneviève/ ROGNON, Pierre (dir.)-CE. MED-CAMPUS-Désertification et aménagement au Maghreb. Cours des séminaires-Séminaires de Medenine (Tunisie) et Agadir (Maroc), 1993-Paris-L'Harmattan-1995-313 p.*
32. *COWI (Consulting Engineers and Planners, Denmark)/ Netherlands Economic Institute/ Andante, Sweden-Evaluation of aspects of EU development aid to the MED region. Final synthesis report.-1998-60 p. + annexes*
33. *Croatia. Ministry of Environmental Protection, Physical Planning and Housing-National report on Environment and Development (prepared for UNCED 92)- Zagreb (HRV)-1992-51 p.*
34. *Cyprus. Ministry of Agriculture and Natural Resources/Council for the Protection of the Environment-National Report to the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, 1992-Nicosie (CYP)-Government of Cyprus-1992-56 p.*
35. *DALIGAUX, Jacques Urbanisation et société locale en Provence-Paris-L'Harmattan-1999-267 p.*
36. *DOMENACH Hervé, PICOUET Michel- Population et environnement-Paris-PUF-2000-127 p.*
37. *DUCHAUFOUR Ph. Pédologie, Masson, 1988, 224p.*
38. *EC. DG XI (Environment, Nuclear Safety and Civil Security). LIFE Programme/ Malta. Environment Protection Department-Evaluation of pollution risk and prevention measures in Malta-1999-105 p.*
39. *EC. DG Agriculture/ EC. Joint Research Centre/ EC. Eurostat / EC. European Environment Agency-From land cover to landscape diversity in the European Union-2000-112 p.*
40. *EEA (European Environment Agency)-Europe's Environment: The Second Assessment-Luxembourg-Office for Official Publications of the European Communities-1998-293 p.*
41. *EEA (European Environment Agency)-Environment in the European Union at the turn of the century-Copenhague-EEA-1999-446 p.*
42. *EEA (European Environment Agency)/ UNEP-Down to earth: soil degradation and sustainable development in Europe. A challenge for the 21st century-Luxembourg-Office for Official Publications of the European Communities-2000-32 p.*
43. *EEA (European Environment Agency)/ UNEP-State and pressures of the marine and coastal Mediterranean environment-Luxembourg-Office for Official Publications of the European Communities-1999-137 p.*
44. *EEAA (Egyptian Environmental Affairs Agency)-The environment in Egypt 1996-Cairo-EEAA-1997-88 p.*
45. *ENNE, G. (ed.)/ D'ANGELO, M. (ed.)/ ZANOLLA, C. (ed.)-ANPA (Agenzia Nazionale per la Protezione dell'Ambiente)/ Italia. Universita di Sassari. Nucleo Ricerca Desertificazione-Indicators for assessing desertification in the Mediterranean-Proceedings of the International Seminar, Porto-Torres (Italy), 18-20 September 1998-1998-333 p.*
46. *Espagne. Ministère des Travaux Publics et de l'Urbanisme/Agencia de Medio Ambiente (ESP)-Degradación de zonas áridas en el entorno Mediterráneo-Journées Internationales, Madrid, 25-27 mai 1987-Madrid-MOPU-1989-224 p.*
47. *Espagne. Ministère des Travaux Publics et des Transports-España. Conferencia Medio Ambiente y Desarrollo, UNCED, Brasil-92-Madrid-MOPT-1992-103 p.*
48. *Espana. Ministerio de Obras Publicas y Transportes-Guia para la elaboracion de estudios del medio fisico. Contenido y metodologia-Madrid-Ministerio de Obras Publicas y Transportes-1992-809 p.*
49. *Espana. Ministerio de Obras Públicas y Urbanismo. Dirección General del Medio Ambiente -Desertificación en Europa-Simposium de Información sobre Climatología en el Programa de la CEE. Mytilene, Grèce, 15-18 avril 1984-Madrid-MOPU-1988-317 p.*
50. *Espana. Ministerio de Obras Públicas y Urbanismo, Dirección General del Medio Ambiente-Guías metodológicas para la elaboración de estudios de impacto ambiental. 3. Repoblaciones forestales-Madrid-MOPU-1989-181 p.*
51. *Espana. Ministerio de Obras Publicas y Transportes/Instituto Geográfico Nacional-Atlas Nacional de España - Sección X, Grupo 39: Problemas medioambientales-Madrid-Instituto Geográfico Nacional-1991-16 p.*

52. ESSC (European Society for Soil Conservation)-Abstracts book-Key notes-Third International Congress "Man and soil at the third millenium", Valencia (Spain), 28 March-1 April 2000-2000-450 p.; 173 p.

53. European Commission-Declaration of the Euro-Mediterranean ministerial conference on the environment, Helsinki, 28 november 1997-1997-44 p.

54. European Commission. DG Environment-The law of sustainable development: general principles-Luxembourg-Office for Official Publications of the European Communities-2000-145 p.

55. European Parliament. Directorate General for Research. STOA -Sustainable Development in the Mediterranean Region: The Challenges and the Policy Instruments. Working Documents for the Project Steering Group-Vol. 1(A) - Human Activities and their Effects on the Mediterranean Environment-Vol. 1(B) - State of the Environment in the Mediterranean Region-Vol. 3 - Data on the Economic Situation of the EU-Mediterranean Member States-Vol. 4 - Assessment of EU Policy Instruments for Development in the EU Mediterranean Regions-4 vol.-Luxembourg-STOA-1996-57 p. + 66 p. + 11 p. + 49 p.

56. FAO- Protéger et produire: comment reconstituer le puzzle-Rome-FAO-1993-36 p.

57. FAO- La conservation et la restauration des terres en Afrique: un programme international-Oxford (GBR)-Words and Publications-1988-38 p.

58. FAO. Land and Water Development Division-Land resource potential and constraints at regional and country levels-Rome-FAO-2000-114 p.

59. FARVACQUE-VITKOVIC, Catherine/ MCAUSLAN, Patrick- Politiques foncières des villes en développement-Paris-ADEF-1993-155 p.

60. FINKE, P./ HARTWICH, R./ DUDAL, R./ IBANEZ, J./ JAMAGNE, M./ KING, D./ MONTANARELLA, L./ YASSOGLOU, N.-EC. European Soil Bureau/ SAI (Space Application Institute)/ EC. Joint Research Centre-Georeferenced soil database for Europe. Manual of procedures. Version 1.0-1998-170 p.

61. Fondation Charles Léopold Mayer pour le Progrès de l'Homme/ Projet Tutzing "Ecologie du Temps"-Préserver les sols, source de vie. Proposition d'une Convention sur l'utilisation durable des sols-Paris-Editions Charles Léopold Mayer-1998-150 p.

62. France. Ministère de l'Environnement/ CESTA (Centre d'Etudes des Systèmes et des Technologies Avancées)-Pour une politique scientifique internationale de l'environnement. Document préparatoire français-Paris-CESTA-1985-225 p.

63. GENDEBIEN, A. / REES, Y./ HARRIS, N./ ZABEL, T./ CRATHORNE, B.-Environment Agency (GBR)/ SNIFFERS (Scotland and Northern Ireland Forum for Environmental Research)-Controlling Pollution from Diffuse Sources. Approaches taken in Selected Member States-Bristol (GBR)-Environment Agency-1997-98 p.

64. GRAAFF, J. de-The price of soil erosion: an economic evaluation of soil conservation and watershed development- Wageningen (NLD)-Agricultural University-1996-298 p.

65. GRADUS, Yehuda (ed.) / LIPSHITZ, Gabriel (ed.)-Negev Center for Regional Development-The mosaic of Israeli geography-Beer-Sheva (ISR)-Ben-Gurion University of the Negev Press-1996-516 p.

66. Greece. Ministries of Foreign Affairs, National Economy and Environment, Physical Planning and Public Works-National Report of Greece to UNCED '92-Athènes-1992-131 p.-(sur disquette)

67. HETTELINGH, Jean-Paul/VAN EGMOND, Klaas/MAAS, Rob-Netherlands. RIVM (National Institute of Public Health and Environmental Protection)-European Environmental Data and Scenarios: Perspectives Towards Sustainability-Bilthoven (NLD)-RIVM-1992-31 p.

68. HODGSON, J.M. (ed.)-CEC (Commission of the European Communities)-Soil Survey: a basis for European soil protection-Proceedings of the meeting of European Heads of Soil Survey, Silsoe (GBR), 11-13 December 1989-Luxembourg-Office for Official Publications of the European Communities-1991-214 p.

69. HUYBRECHTS Eric-PNUE/PAM/Plan Bleu, PNUE/PAM/CAR-PAP, CMDD (Commission Méditerranéenne du Développement Durable)- L'urbanisation et la gestion des villes dans les pays méditerranéens. Etude sub-regionale: Liban, Syrie, Turquie. Document préparé pour la Réunion méditerranéenne "Gestion des villes et développement durable", Barcelone, 3-5 septembre 2001-Sophia Antipolis- Plan Bleu-2001-57 p.

70. ICALPE (Centre International pour l'Environnement Alpin)- Montagnes et forêts méditerranéennes Atelier international sur l'agriculture et la transformation des terres dans le bassin méditerranéen, Montpellier, France, juin 1988-Le Bourget-du-Lac-ICALPE-1992-128 p.

71. IFEN (Institut Français de l'Environnement)- L'environnement en France- Orléans (FRA)-IFEN-1999-472 p.

72. Institut de la Méditerranée- MEDA. Etat des lieux du processus de Barcelone 1995-2000: cinquième anniversaire-Marseille-Institut de la Méditerranée-2000-63 p.

73. Italia. Comitato Nazionale per la Lotta alla Desertificazione/ Italia. Ministero dell' Ambiente-Comunicazione nazionale per la lotta alla siccita ed alla desertificazione-1999-115 p.

74. Italia. Ministero dell' Ambiente-Relazione sullo stato dell' ambiente-1997-446 p.

75. Italia. Ministero dell'Ambiente-Report on the State of the Environment in Italy-2 vol. -Rome-Ministero dell'Ambiente-1992-487+6 p.

76. JEFTIC, L. (ed.)/MILLIMAN, J.D. (ed.)/SESTINI, G. (ed.)-Climatic Change and the Mediterranean. Environmental and Societal Impacts of Climatic Change and sea-level Rise in the Mediterranean Region-Nairobi; Londres-UNEP; Edward Arnold-1992-673 p.

77. *JONG, Stephen M. de-Universiteit Utrecht, Faculteit Ruimtelijke Wetenschappen (NLD)-Thesis-Applications of Reflective Remote Sensing for Land Degradation Studies in a Mediterranean Environment-Utrecht (NDL)-1994-256 p.*

78. *KOSMAS, C. (ed.)/ KIRKBY, M. (ed.)/ GEESON, N. (ed.)-EC. DG XII (Science, Research and Development)-The Medalus project Mediterranean desertification and land use. Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification-Luxembourg-Office for Official Publications of the European Communities-1999-87 p.*

79. *KUZUCUOGLU, Catherine -PNUE/PAM/Plan Bleu-Des problématiques aux indicateurs: l'exemple des sols-Sophia Antipolis-Plan Bleu-1996.*

80. *La forêt méditerranéenne-Unasylva, n°197, 1999-Rome-FAO-1999-pp. 2-51*

81. *LA ROCHEFOUCAULD, Bernard de-L'abondance foncière. Une attitude industrielle appliquée à l'espace-Paris-Dunod-1982-182 p.*

82. *LAVOUX, Thierry (dir.)/ RECHATIN, Cécile (dir.)-IFEN (Institut Français de l'Environnement)-L'environnement en France. Edition 1999-Paris-La Découverte-1998-480 p.*

83. *Liban. CDR (Conseil du Développement et de la Reconstruction)/ IAURIF (Institut d'Aménagement et d'Urbanisme de la Région d'Ile-de-France)-Evaluation environnementale de la côte du Liban. Rapport thématique planification-Paris-IAURIF-1999-159 p.*

84. *LOUHICHI, Kamel-Thèse Master of Science-Utilisation d'un modèle bio-économique pour analyser l'impact des politiques agri-environnementales: cas des techniques de conservation des eaux et du sol en Tunisie. Application à la ferme Sawaf-Master of Science n°39-Montpellier (FRA)-CIHEAM-1997-128 p.*

85. *LOWDERMILK W.C.-Conquest of the land through seven thousand years-Washington D.C.-US Department of Agriculture-1948-36 p.*

86. *MARGAT Jean, VALLEE Domitille-PNUE/PAM/Plan Bleu-Water resources and uses in the Mediterranean countries: figures and facts = Ressources en eau et utilisations dans les pays méditerranéens: repères et statistiques-Sophia Antipolis-Plan Bleu-1999-224 p.*

87. *Maroc. Ministère de l'Agriculture et de la Mise en Valeur Agricole/ Maroc. Ministère Chargé des Eaux et Forêts-Plan national d'aménagement des bassins versants-1995/ 1999-47 p.; 18 p.*

88. *Maroc. Ministère de l'Environnement. Observatoire National de l'Environnement du Maroc (ONEM) / ECODIT-Stratégie nationale pour la protection de l'environnement et le développement durable-Rabat-ONEM-1995-128 p.*

89. *Maroc. Ministère de l'Intérieur et de l'Information. Direction Générale de l'Urbanisme, de l'Aménagement du Territoire et de l'Environnement-Rapport National pour la Conférence des Nations Unies sur l'Environnement et le Développement, Rio de Janeiro, 1-12 juin 1992-Rabat-1992-136 p.*

90. *Maroc. Ministère de l'Intérieur-Vers une stratégie marocaine en matière d'environnement-Conférence Ministérielle sur l'environnement dans la région méditerranéenne, Casablanca, Maroc, 24-25 mai 1993-Rabat-1993-31 p.*

91. *MEDIMONT-Coordination Report. Meeting on History and impacts of land use changes, Basilicate et Calabre, Italie, 4-6 mai 1993 -1993-6 p.*

92. *METAP-Tripoli/El-Mina Environmental Audit. Draft-Washington D.C.-1993-139 p.*

93. *MIDDLETON, Nick (ed.) / THOMAS, David (ed.)-UNEP-World Atlas of Desertification-2nd ed.-London-Arnold-1997-182 p.*

94. *MONTGOLFIER, Jean de-Les espaces boisés méditerranéens: situation et perspectives-Paris; Sophia Antipolis-Economica; Plan Bleu-2002 (à paraître)-(Les Fascicules du Plan Bleu n°12)*

95. *MOREY, Miguel (dir.)-Espana. Comité Español del programa MAB / Espana. Dirección General del Medio Ambiente-Estudio integrado de la isla de Formentera. Bases para un ecodesarrollo-Madrid-MOPT-1992-231 p.*

96. *MORGAN, R.P.C.-Soil erosion and conservation-2nd ed.-Harlow (GBR)-Longman-1996-198 p.*

97. *MTIMET, Amor/ LASRAM, Mustapha (préf.)-Tunisie. Ministère de l'Agriculture-Atlas des sols tunisiens-Tunis-Ministère de l'Agriculture-1999-166 p.*

98. *NARJISSE, H.-Maroc. Ministère de l'Environnement. Direction de l'Observation, des Etudes et de la Coordination/ Maroc. Ministère de l'Agriculture et de la Mise en Valeur Agricole. Cellule de l'Environnement-Action 30. Plan d'Action National pour l'Environnement. Atelier sol et environnement. Version provisoire. Note technique-Atelier Sol et environnement, Marrakech, 7-8 janvier 1997-Rabat-ONEM-1997-123 p.*

99. *OCDE-Politiques menées par les pouvoirs publics pour protéger les ressources en sols-Paris-OCDE-1994-89 p.*

100. *OCDE-Examens des performances environnementales. Portugal-Paris-OCDE-1993-158 p.*

101. *OCDE-OECD Core Set of Indicators for Environmental Performance Reviews. A synthesis report by the Group on the State of the Environment-Paris-OCDE-1993-35 p.*

102. *OCDE/ CEMT (Conférence Européenne des Ministres des Transports)-Transports urbains et développement durable-Paris-OCDE-1995-268 p.*

103. *OCDE-L'agriculture durable. Questions de fond et politiques dans les pays de l'OCDE-Paris-OCDE-1995-77 p.*

104. *OLDEMAN, L.R./ HAKKELING, R.T.A./ SOMBROEK, W.G.-UNEP/ ISRIC-Global Assessment of Soil Degradation (GLASOD). World map of the status of human-induced soil degradation: an explanatory note-2nd ed.-Wageningen; Nairobi-ISRIC; UNEP-1991-34 p.*

105. *ONU-Action 21: Déclaration de Rio sur l'environnement et le développement. Déclaration de principes relatifs aux forêts. Conference des Nations Unies sur l'Environnement et le Développement (CNUED), Rio de Janeiro, Brésil, 3-14 juin 1992-New York-ONU-1993-294 p.*

106. *OUESLATI, Walid-Faculté des Sciences Economiques et de Gestion de Tunis-Mémoire pour l'obtention du Diplôme d'Etudes Approfondies en Sciences Economiques-De la soutenabilité du développement: concept et mesure (Application à la Tunisie)-Chapitre III: De la mesurabilité du développement soutenable: une tentative de construction d'indicateurs pour la Tunisie-Tunis-1995-48 p.*

107. *Palestinian Authority. Ministry of Planning and International Cooperation-Emergency natural resources protection plan for Palestine. West Bank governorates-1998-55 p.*

108. *Palestinian Central Bureau of Statistics-Institutions capability in land use and geographic information system (GIS): main findings-Ramallah (PAL)-Palestinian Central Bureau of Statistics-1999*

109. *Palestinian Central Bureau of Statistics-Area statistics in the Palestinian Territory-Ramallah (PAL)-Palestinian Central Bureau of Statistics-1998*

110. *PNUE/ PAM-Plan d'action pour la Méditerranée et Convention sur la protection du milieu-marin et du littoral de la Méditerranée et ses protocoles-Athènes-PAM-1997-168 p.*

111. *PNUE/ PAM/ CAR-PAP-Directives pour la gestion de programmes de contrôle d'érosion et de désertification, plus particulièrement destinées aux zones côtières méditerranéennes-Split-CAR-PAP-2000-115 p.*

112. *PNUE/ PAM/ CAR-PAP-Rapport de l'atelier sur l'état de l'érosion des sols par la pluie dans les zones côtières méditerranéennes, Murcie (ESP), 23-25 novembre 1988-Murcie (ESP)-CAR-PAP-1988-12 p.*

113. *PNUE. PAM. CAR-PAP / FAO-Directives pour l'application d'une méthodologie commune et consolidée de cartographie des processus d'érosion hydrique dans les zones côtières méditerranéennes-Split-CAR-PAP-1996-112 p.*

114. *PNUE. PAM. CAR-PB-Agriculture et développement rural en Méditerranée. Etude de faisabilité pour la Commission Méditerranéenne du Développement Durable (CMDD)-Sophia Antipolis-Plan Bleu-2001*

115. *PNUE/PAM/Plan Bleu-L'étalement urbain en Méditerranée-Sophia Antipolis-Plan Bleu-2001-5 p.*

116. *PNUE/PAM/Plan Bleu, PNUE/PAM/CAR-PAP, CMDD (Commission Méditerranéenne du Développement Durable)-Gestion des villes et développement durable en Méditerranée. Projet de rapport pour la Réunion extraordinaire de la CMDD, Monaco, 12 novembre 2001-Sophia Antipolis-Plan Bleu-2001-71 p.*

117. *PNUE. PAM. CAR-PB-Profil Liban-Sophia Antipolis (FRA)-Plan Bleu-1999-66 p.*

118. *PNUE. PAM. CAR-PB-Profil Tunisie-Sophia Antipolis (FRA)-Plan Bleu-2000-90 p.*

119. *PNUE. PAM. CAR-PB-Suivi de l'évolution du littoral à partir des données LACOAST: réflexions méthodologiques pour la Méditerranée. Exemple de la France-Sophia Antipolis (FRA)-Plan Bleu-2000-96 p.*

120. *PNUE. PAM. CAR-PB-Suivi de l'évolution du littoral à partir des données LACOAST: littoral méditerranéen français-Sophia Antipolis (FRA)-Plan Bleu-2000-43 p.*

121. *PNUE/PAM/Plan Bleu-L'urbanisation en Méditerranée de 1950 à 1995-Sophia Antipolis-Plan Bleu-2001-(Les Cahiers du Plan Bleu, n°1)-45 p.*

122. *PNUE/PAM/Plan Bleu-Villes et développement durable en Méditerranée.-Sophia Antipolis-Plan Bleu-2000-5 p.*

123. *PRIEUR, Michel/ GHEZALI, Mahfoud-PNUE. PAM. CAR-PAP-Législations nationales relatives à l'aménagement et à la gestion des zones côtières en Méditerranée et propositions de lignes directrices-Split-Programme d'Actions Prioritaires-2000-88 p.*

124. *PRIEUR, Michel (dir.)-Université de Limoges. Faculté de Droit et des Sciences Economiques/ CNRS. CRIDEAU-URA 967, Limoges / Centre International de Droit Comparé de l'Environnement-La protection juridique des sols dans les Etats Membres de la Communauté Européenne-Limoges (FRA)-PULIM-1993-218 p.*

125. *RAMADE François-Dictionnaire encyclopédique de l'écologie et des sciences de l'environnement-Paris-Ediscience-1993-822 p.*

126. *REYNAUD, Christian et al./ BATISSE, Michel (préf.)-PNUE. PAM. CAR-PB-Transports et environnement en Méditerranée. Enjeux et prospective-Sophia Antipolis (FRA); Paris -CAR-PB; Economica-1996-250 p. -(Les Fascicules du Plan Bleu, n°9)*

127. *ROGNON Pierre-Comment lutter contre la désertification-Manière de Voir, n°59, septembre-octobre 2001-Paris-Le Monde Diplomatique-2001-pp. 18-20*

128. *ROOSE Eric-FAO-Introduction à la gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES)-Rome-FAO-1994-420 p.*

129. *ROOSE, Eric-ORSTOM-Conservation des sols en zones méditerranéennes. Synthèse et proposition d'une nouvelle stratégie de lutte antiérosive: la GCES-Cahiers ORSTOM, Série Pédologie, vol. XXVI, n°2, 1991-1991-pp. 145-181*

130. *ROOSE Eric, SABIR Mohammed, MACHOURI Nadia, ABDELFETA Nouri-Première approche de la GCES au Maroc. Enquête sur les risques de ruissellement et d'érosion à l'échelle de deux terroirs du Rif (région de Tétouan). Comparaison du diagnostic des villageois et des scientifiques-**2000 ?**-21 p.*

131. *ROSSI, Georges/ BERTRAND, Georges (préf.) -L'ingérence écologique: environnement et développement rural du Nord au Sud-Paris-CNRS-Editions 2000-248 p.*

132. *SELMI, Salah/ NASRI, Slah-ORSTOM/ Tunisie. INGREF/ Hydromed-Les lacs et retenues collinaires en Tunisie-Tunis-1997-53 p.*

133. *SKOURI Mohamed-Les dégradations du milieu et les mesures de protection-Comptes Rendus de l'Académie d'Agriculture de France, 80, n°9, 1994-1994-pp. 49-82*

134. *STANNERS, David (ed.)/ BOURDEAU, Philippe (ed.). European Environment Agency -Europe's Environment: The Dobris Assessment -Luxembourg, Office for Official Publications of the European Communities -1995 - Chapter 7: Soil -pp. 146-171*

135. *ORSTOM -Actualités n°56 - Spécial érosion -Paris-ORSTOM-1998-41 p.*

136. *STAHL, Paul Henri-Propriété et structure sociale: 19-20ème siècles-Aix en Provence (FRA); Casablanca; Tunis-Edisud; Toubkal; Alif-1997-88 p.*

137. *TIERCELIN, Jean-Robert-FAO. SNEA (Bureau sous-régional pour l'Afrique du Nord)-Eaux et sols de l'Afrique du Nord: Mauritanie, Maroc, Algérie, Tunisie, Libye. Rapport de synthèse-1999-50 p.*

138. *Tunisie. Ministère de l'Agriculture-Sols de Tunisie-Bulletin de la division des sols, n°8, 1976-Tunis-Ministère de l'Agriculture-1976-90 p.*

139. *Tunisie. Ministère de l'Environnement et de l'Aménagement du Territoire-Rapport National: l'Etat de l'Environnement-Tunis-Ministère de l'Environnement et de l'Aménagement du Territoire-1996-118 p.*

140. *Tunisie. Ministère de l'Environnement et de l'Aménagement du Territoire-Rapport National: l'Etat de l'Environnement-Tunis-Ministère de l'Environnement et de l'Aménagement du Territoire-1998-104 p.*

141. *Tunisie. Ministère de l'Environnement et de l'Aménagement du Territoire-Rapport National: l'Etat de l'Environnement-Tunis-Ministère de l'Environnement et de l'Aménagement du Territoire-1999-156 p.*

142. *Tunisie. Ministère de l'Environnement et de l'Aménagement du Territoire / PNUE. PAM-Agenda MED 21. Conférence ministérielle sur le développement durable en Méditerranée, Tunis, 1er novembre 1994-Tunis-Ministère de l'Environnement et de l'Aménagement du Territoire-1995-157 p.*

143. *Turkey. Prime Ministry State Planning Organization-Turkey. National Environmental Action Plan-Ankara-1998-77 p. + annexes*

144. *UNEP/MAP/Plan Bleu, UNEP/MAP/PAP-RAC, MCSD (Mediterranean Commission on Sustainable Development)-CONSTANTINIDES Glafkos-Urbanisation and town management in the Mediterranean countries. Sub-regional study: Malta and Cyprus. Paper prepared for the Mediterranean Meeting on "Urban management and sustainable development", Barcelona, 3-5 September 2001-Sophia Antipolis-Plan Bleu-2001-38 p. + annexes*

145. *UNEP. MAP. PAP-RAC-Rapports nationaux sur les problèmes et les pratiques de lutte anti-érosive en région méditerranéenne-Split-PAP-RAC-2000-162 p.*

146. *UNEP. MAP. PAP-RAC-Report of the expert meeting on the implementation of the pilot project on soil erosion mapping and measurement in the Mediterranean coastal zones, Malaga, December 12-14, 1989-Malaga-PAP-RAC-1989-9 p.*

147. *UNEP. MAP. PAP-RAC-Report of the Seminar on the results of the sub-project on mapping of erosion processes in the Mediterranean coastal zones, Malaga, December 2-4, 1992-Malaga-PAP-RAC-1992-14 p.*

148. *UNEP. MAP. PAP-RAC/ FAO-Directives pour la cartographie et la mesure des processus d'érosion hydrique dans les zones côtières méditerranéennes-Split-PAP-RAC-1998-72 p.*

149. *UNEP/MAP/PAP-RAC-White paper: coastal zone management in the Mediterranean-Split-Priority Actions Programme-2001-74 p.*

150. *United Nations. ECE (Economic Commission for Europe). Statistical Division-Conference of European statisticians. Readings in international environment statistics-New York-United Nations-1993-534 p.*

151. *Université de Reims. Institut de Géographie-Etudes algériennes-Reims (FRA)-ERIGUR-1994-138 p.*

152. *Université de Nice. Laboratoire d'Analyse Spatiale Raoul Blanchard-Aménagement & Gestion du territoire ou l'apport des images-satellite, de la géo-infographique et du terrain. Applications aux paysages végétaux de l'Algérie steppique & sub-steppique (Wilaya de Tiaret) et aux espaces construits (Tiaret & Alger). 1990-1992-Nice (FRA)-Université de Nice-1992-253 p.*

153. *USA. Department of State. US National Committee for MAB-Draft Environmental Profile on Egypt-Washington D.C.-US MAB-1980-109 p.*

154. *VALK Watsien, DE GRAAFF Jan-Wageningen Agricultural University-Social and economic aspects of soil and water conservation-Wageningen-Wageningen Agricultural University-1997*

155. *VAN DER KNIJFF, J.M./ JONES, R.J.A./ MONTANARELLA, Luca/ CHRISTOPHE, Sidonie (trad.)-EC. European Soil Bureau/ SAI (Space Application Institute)/ EC. Joint Research Centre-Estimation du risque d'érosion en Italie-2000-45 p.*

156. *VAN DER LEEUW, S.E. (ed.)-University of Cambridge (GBR)/ Commission of the European Union. DG XII-Understanding the Natural and Anthropogenic Causes of Soil Degradation and Desertification in the Mediterranean Basin. Vol 6: Synthesis. The Archaeomedes Project Vera Basin, the Argolid, Epirus, southern Rhône valley-Cambridge (GBR)-1994-438 p.*

157. *VELKAVRH, Anita-MCSD (Mediterranean Commission on Sustainable Development)/ UNEP. MAP. BP-RAC-Sustainable Mediterranean indicators tested in Slovenia-Indicators for the sustainable development in the Mediterranean region. Sophia Antipolis, 10-11 mai 1999-1999*

158. *VEYRET, Yvette (coord.)/ BALLAIS, Jean-Louis/ MARRE, Alain / MIETTON, Michel / MIOSSEC, Alain / MORIN, Serge / VALADAS, Bernard-L'érosion entre nature et société-Paris-Sédès-1998-344 p.*

159. *VIEL, Monique (ed.)-UNEP. MAP. ERS-RAC/ EC. DG XII (Science, Research and Development)-RESSAC: Remote Sensing Support for Analysis of Coasts-Palermo (ITA)-ERS-RAC-1999-131 p.*

160. *WOLMAN, M.G. (ed.)/ FOURNIER, F.G.A. (ed.)-Land transformation in agriculture-Chichester (GBR)-Wiley-1987-531 p.*

161. *World Bank-Expanding the measure of wealth: indicators of environmentally sustainable development-Washington D.C.-World Bank-1997-110 p.*

162. *ZUNICA, Marcello-Ambiente costiero e valutazione d'impatto-Bologne (ITA)-Pàtron Editore-1992-204 p.*

PLAN BLEU PUBLICATIONS

- **Le Plan Bleu. Avenirs du Bassin Méditerranéen**
Futures for the Mediterranean Basin. The Plan Bleu
Michel Grenon et Michel Batisse
French ed.: Economica, Paris, 1989
English ed.: Oxford University Press, 1989
Spanish ed.: MOPU, Madrid, 1990
Arabic ed.: Edifra, Paris, 1991
Turkish ed.: Çevre Bakanligi, Ankara, 1993

- **L'eau en région méditerranéenne. Situations, perspectives et stratégies pour une gestion durable de la ressource**
Water in the Mediterranean Region. Situations, perspectives and strategies for sustainable water resources management
Mohamed Benblidia, Jean Margat et Domitille Vallée
Bilingual document (French-English) prepared for the Euro-Mediterranean Conference on Water Management, Marseille, 25-26 November 1996
Plan Bleu, Sophia Antipolis, 1997

- **Les indicateurs d'économie de l'eau: ressources et utilisations**
Plan Bleu, Observatoire du Sahara et du Sahel, Paris, 1996

- **Vision méditerranéenne sur l'eau, la population et l'environnement au XXIème siècle**
Mediterranean vision on water, population and the environment for the 21st century
Jean Margat et Domitille Vallée
Document prepared in the World Water Vision programme
Plan Bleu, Sophia Antipolis, 2000

- **130 indicateurs pour le développement durable en Méditerranée**
130 indicators for the sustainable development in Mediterranean region
Plan Bleu, Sophia Antipolis, 2000

LES FASCICULES DU PLAN BLEU

Serie edited by Michel Batisse. Ed. Economica, Paris

1. **Pêche et aquaculture en Méditerranée. Etat actuel et perspectives.** Daniel Charbonnier et al., 1990
2. **Les forêts méditerranéennes. Enjeux et perspectives.** Henri Marchand et al., 1990
3. **Conservation des écosystèmes méditerranéens. Enjeux et prospective.** François Ramade et al., new edition 1997
4. **Industrie et environnement en Méditerranée. Evolution et perspectives.** Jacques Giri et al., 1991
5. **Les îles en Méditerranée. Enjeux et perspectives.** Louis Brigand et al., 1992
6. **L'eau dans le Bassin méditerranéen. Situation et prospective.** Jean Margat et al., 1992
7. **Energie et environnement en Méditerranée. Enjeux et prospective.** Michel Grenon et al., 1993
8. **Tourisme et environnement en Méditerranée. Enjeux et prospective.** Robert Lanquar et al., 1995
9. **Transports et environnement en Méditerranée. Enjeux et prospective.** Christian Reynaud et al., 1996
10. **Les risques naturels en Méditerranée. Situation et perspectives.** Adelin Villevielle et al., 1997
11. **La démographie en Méditerranée. Situation et projections.** Isabelle Attané, Youssef Courbage et al., 2001
12. **Les espaces boisés méditerranéens. Situation et perspectives.** Jean de Montgolfier et al., 2002

"MEDITERRANEAN COUNTRY PROFILES" SERIES

Plan Bleu, Sophia Antipolis

- **"Institutions - Environnement - Développement"**
Albania, Turkey, Tunisia, Morocco. 1995
Egypt. 1996
Algeria. 1998 (French and English)

- **New series "Problématiques et Politiques d'Environnement et de Développement Durable"**
Lebanon. 1999 (French and English)
Tunisia. (French and English)

MAP TECHNICAL REPORTS SERIES

Mediterranean Action Plan, Athens
E-mail: unepmedu@unepmap.gr
Site web: www.unepmap.org
Fax: + 30 (210) 1 725 31 96/7

- **Actes du séminaire débat sur la prospective méditerranéenne. 19-21 Octobre 1992**
MAP Technical Reports Series n°88, 1994

- **Iskenderun Bay Project:**
Vol. I: Environmental Management within the context of Environment-Development
MAP Technical Reports Series n°89, 1994
Vol. II: Systemic and Prospective Analysis
MAP Technical Reports Series n°90, 1994

- **Une contribution de l'écologie à la prospective des régions côtières de la Méditerranée. Problèmes et acquis.**
S.I. Ghabbour
MAP Technical Reports Series n°91, 1994

- **Méthodes et outils pour les études systémiques et prospectives en Méditerranée.**
MAP Technical Reports Series n°115, 1996

- **Rapport de l'atelier sur le tourisme et le développement durable en Méditerranée.**
Antalya, Turkey, 17-19 September 1998
(French and English)
MAP Technical Reports Series n° 126, 1999

- **Actes du séminaire "La prospective territoriale en Méditerranée et l'approche par acteurs".**
Sophia Antipolis (France), 7-9 November 1996
(French and English)
MAP Technical Reports Series n°127, 1999

THE PLAN BLEU PAPERS

- **L'urbanisation en Méditerranée de 1950 à 1995**
PNUE, PAM, Plan Bleu, 2001
(French and English)
Plan Bleu Papers Series n°1, 2001

THE PLAN BLEU NOTES

- **L'eau l'environnement et la population en Méditerranée au XXIème siècle**
Water, population and the environment in the Mediterranean for the 21st century
PNUE, PAM, Plan Bleu
(French and English)
Plan Bleu Notes Series n°1, 2000

- **Mieux gérer les demandes en eau pour dépasser les situations de crise en Méditerranée**
Better water demand management for overcoming water crisis in the Mediterranean
Plan Bleu
(French and English)
Plan Bleu Notes Series n°2, 2003

OTHER PUBLICATIONS

Many studies, data, figures and Plan Bleu publications can be downloaded on the website http://www.planbleu.org

Legal deposit: May, 2003.

United Nations Environment Programme

•

Mediterranean Action Plan

•

Plan Bleu
Regional Activity Centre

The intention of the "Plan Bleu Papers Series", in addition to the "Fascicules" (published by Economica Paris) and "Country Profiles", is to provide basic summary information in English and French on the major issues or tools and methods dealing with sustainable development in the Mediterranean region.

The present "Plan Bleu Paper" is the second in the series and focuses on the problems related to soil degradation in the Mediterranean region from a documents-review perspective. It describes the present state of Mediterranean soils, investigates the main threats to them and looks at the national and international institutional context in which policies for combating soil degradation are trying to be implemented.

It appears that in general data on soils are often very incomplete and sometimes even contradictory, depending on the sources consulted. Erosion, which is by far the best-documented phenomenon in the Mediterranean, is said by the FAO to affect about 15 per cent of the Mediterranean's lands. It would also appear that the loss of organic matter from soils is a recurrent problem. Soil capping by humans does not originate for the same reasons on the northern shore of the Mediterranean, where it is above all else a life-styles- and space-consumption-related problem, as on the southern where demographic pressure around cities and towns is accelerating land consumption. The problems due to poorly managed intensive farming are seen in both North and South, whereas degradation caused by very poor agriculture is specific to the South. In the North the sometimes very marked abandonment of farming can lead to the disappearance of very soil and water conservation works and a loss of diversity in the countryside.

The paper also observes that co-ordination is often extremely insufficient between sectoral policies as well as between various geographical levels. Several authors stress the too-frequent lack of effective means allocated to soil conservation.

Plan Bleu
for Environment and Development in the Mediterranean Region

15, rue Beethoven,
Sophia Antipolis,
F-06560 Valbonne
Tel: +33 (0)4 92 38 71 30,
Fax: +33 (0)4 92 38 71 31
www.planbleu.org
planbleu@planbleu.org

ISBN: 2-912081-14-9
Price: 10 €