



European desertification

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Abstract

Desertification refers to land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Areas affected by desertification processes lose progressively their level of biological quality and productivity. In Europe, desertification processes affect approximately 10% of the total land area. The Mediterranean and Eastern European Regions are specially threatened by desertification due to natural and economic pressures. This paper deals with the factors and causes of desertification at European level. The most important impacts and consequences of desertification processes are outlined. Finally, the current perspectives to effectively undertake the issue of desertification are described, focusing on the possibilities offered by the united Nations Convention to Combat Desertification.

1 Introduction

Desertification is one of the most serious environmental issues at a global scale. In its last consequences represents the total destruction of the biological potentiality of the affected territory. Under the term



desertification are included various processes that act diminishing gradually and progressively the capacity of the land to support vegetation and animal communities, agriculture, forestry and other land uses (e.g. nature conservation, recreation).

Areas affected by desertification processes loose progressively their level of biological quality and productivity. Similarly to other degradation processes, desertification starts when the ecological equilibrium of soil in terms of inputs and outputs of energy and matter is broken. As a consequence, the physical, chemical and biological functions of soil are seriously altered and even irreversibly damaged in advanced stages. This has negative influences to other ecosystem components and functions: hydrological cycle, vegetation succession, biomass production, filtering, buffering, etc.

Desertification processes affect all dry land zones over the five continents. Almost 900 million people suffer currently the consequences of desertification in the world, and over 5 billion ha (equal to one quarter of the emerged land) are affected by these processes. In total, 98 countries (including 18 developed countries) have some land area affected by desertification.

In Europe, the Mediterranean and Eastern regions are specially threatened by desertification due to natural and economic pressures, which are the main causes for the intensification of the process.

Although the term desertification is new, its consequences were actually known by the old Mediterranean civilisations. However, the universal perception and diffusion of the concept came from the United Nations Conference on Desertification held in Nairobi (Kenya) in 1977, organised by UNEP. This first global Conference on Desertification evaluated the extension and intensity of the processes and established Action Plans to control and mitigate the scope of the problem. Nevertheless, the results were not as good as expected, and also some controversies concerning the scope and meaning of the concept arised. Consequently, the issue of desertification was loosing strength and public interest.

In the Earth Summit held in Rio de Janeiro in June 1992, and by initiative of countries affected by desertification, the UN General Assembly committed itself with the elaboration of an *International convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa (CCD)*. The elaboration of the Convention was intense and fast, and eventually signed in Paris in October 1994 (UNCED¹⁸). It came into force in February 1997 after having been ratified by more than 50 countries.

According to the UN Convention, desertification is the degradation of drylands. The CCD also established the meaning of other

important concepts related to desertification such as “combating desertification”, “land”, “land degradation”, “arid, semi-arid and dry sub-humid areas” and “drought”.

One of CCD’s Annexes concerns the specific problematic of the countries of the Northern Mediterranean region. The other Annexes are respectively dedicated to Africa, Latin America and The Caribbean, and Asia.

The Annex for the Northern Mediterranean region (Annex IV) identifies the particular conditions of the region facilitating the desertification processes. Among others, it specifies the semiarid conditions of the countries of this region (Spain has 63.5 of its territory affected by semiarid conditions, Greece has 62%, Portugal 61.5%, Italy has 40% and France 16%), the seasonal droughts, the very high rainfall variability and the sudden and high-intensity rainfall. It also mentions the incidence of forest fires, the uneven and steep relief favouring the desertification processes, and the abundance of soils and lithologies susceptible to erosion processes.

This Annex also establishes the general framework of action for the Mediterranean Basin. One very important aspect contained in the Annex is the commitment of the affected countries by desertification processes to develop their own National Plan to Combat Desertification. Other important aspect of the Annex is the reference to the co-ordination of subregional, regional and joint Action Programmes, and the co-ordination with other subregions and regions. This framework will make possible to share the knowledge and experience of the affected Mediterranean countries for the design of sound and efficient measures to control the desertification risk.

2 Factors and causes

The main factors and causes of desertification are unsustainable human activities and climatic variability. Within the European context, the intense development occurred in this century by agricultural intensification, urban expansion and infrastructure and other forces at work (e.g. forest fires, tourism) has increasingly led to land degradation. Human pressures causing desertification have been especially intense in Mediterranean and Eastern European countries, where in extensive areas the combined effects of restrictive environmental

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factors (e.g. climate) and inadequate soil management practices have triggered the processes leading to land degradation (Rubio¹⁴; Rubio¹⁵).

The existence of many landscapes in the Mediterranean region with shallow soils, sparse vegetation cover and rock outcrops indicates the intense human action occurred on these countries. Although human pressure has been particularly accentuated over the last decades as consequence of the recent techno-environmental revolution (intensive agriculture, machinery, urban and industrial pressures...), it has been also important for thousands of years due to the accommodation of many civilisations (Pérez-Trejo¹³). For instance, the intense deforestation occurred in the Middle Ages provoked that large sections of sloping land suffered significant soil erosion. These impacts are cumulative along time.

Vegetation of the Mediterranean region has been disturbed from many years, mainly by intensive agriculture, pasture and forest fires. In this context, cultivation has been the most important cause for forest clearance in the Mediterranean region. The extensive deforestation occurred in the Mediterranean region since the first settlements in favour of agriculture resulted in an important reduction of the biological quality of natural systems. The main changes in soil characteristics due to degradation processes are the decrease in organic matter content, increase in salinity, deterioration of soil structure and soil compaction, decrease in water retention capacity and infiltration (Albaladejo¹). The combination of soil degradation with unfavourable climatic conditions led to the formation of extensive marginal and desertified land. In the most fragile areas, as a consequence of forest destruction an accelerated soil erosion process has emerged leading to the rapid formation of badlands characterised for having very erodible soils of very low productivity.

Marginal areas with poor soils not suitable for agriculture were cultivated for many years due to the shortages of food for a growing population. For instance, as a consequence of the need to feed population, the Mediterranean agricultural areas experienced an important increase after the Second World War. Cultivation of marginal areas increased soil erosion due to the lack of adequate soil conservation practices in many areas. This process of soil erosion was intensified with the abandonment of agricultural marginal areas by the rural population, who migrated massively (as consequence of the rapid industrialisation process occurred in the region during the 1950s and 1960s) to urban centres looking for better opportunities. Intensification of soil erosion due to land abandonment from marginal agricultural areas has lead to increase the risk of desertification in extensive areas of the Mediterranean region (UNEP/FAO²¹; Margaris¹⁰; Rubio^{14,15}).

The intensification of agriculture has been the most important change occurred in the Mediterranean region in the last century. Mechanisation, modernisation of farming systems and technological progress are the main responsible factors. Such factors have allowed even the cultivation of agricultural marginal areas. As a consequence of the intensification of agriculture, many land management problems have emerged in the Mediterranean region. In some cases irrigation practices have been responsible for soil salinisation by excessive exploitation of water resources leading to seawater intrusion or by the use of low quality irrigation water and poor drainage. The high demands for water consumption for agriculture and other activities (e.g. industrial-urban uses) has drop intensively the water table favouring conditions for dryness, which increase the susceptibility to desertification.

Pasture causes vegetation degradation when overgrazing occurs. Overgrazing of bushes and young trees by roaming cattle disturbs the dynamic of forests, and when it occurs in burnt forest prevents forest regeneration. Grazing pressure has increasingly occurred since man domesticated animals and concentrated livestock on particular areas. Overgrazing accompanied by fires is dramatically devastating in climatically and topographically marginal areas, which are frequent in the Mediterranean Region. In such areas, soil erosion is easily increased leading to the depletion of the potential productivity of land, and therefore to their desertification.

Fire is an ecological mechanism for the natural regeneration of forest in the Mediterranean region. In fact, man has traditionally used fire in this region as a management tool for temporally increases the extent and palatability of pasture while grazing. However, the forest area burned in the region has intensively increased in the last decades according to the increase in the number of fires occurred. The number of fires and total area burned on forest and other wooded land in Southern Europe has increased greatly during the period 1981-1990 (Eurostat⁶). Most of these forest fires seem to be provoked under urban pressures, mainly in the coastal areas where tourism needs the development of many infrastructures and facilities. In many cases, the consequences of these fires are alarming. For instance, Troeth et al.¹⁷, Halvey et al.⁹ and Andreu et al.³ have reported increasing rates of soil losses after a fire that are several hundred times greater than the pre-fire levels. Furthermore, the last authors also showed that the highest soil nutrient losses were produced in the period immediately after the fire.

The effects of fire on Mediterranean ecosystems have meant the loss of vegetation, fauna and habitats as well as the increase of the risk of soil erosion in many areas. On the other hand, the forest area burned each year is larger than the area replanted. Furthermore, replantation of burned

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areas with coniferous trees is not the most adequate strategy to regenerate the biodiversity characteristic of Mediterranean ecosystems, and moreover cause some problems mainly referred to soil erosion since coniferous trees present high flammability. A new Mediterranean forest policy is now under consideration and discussion trying to solve the above problems (Alcanda Vergara et al.²).

Industrial-urban expansion that occurred in the Mediterranean region over the last decades has been another important factor for increasing the risk of desertification, mainly in coastal areas. Environmental issues such as air, water and soil contamination and landscape deterioration have intensively increased in parallel to the industrial-urban expansion. Of great importance is the loss of productive soils by “*asphaltisation*”. Asphaltisation is considered as the process that lead to the total and irreversible soil loss in an area because of it remains permanently buried by the combined effects of actions and activities of civil engineering, which include the preparation and topographic conditioning of the area to be urbanised, land movements, digging, cementation, building, drainage networks, sewer systems, roads, paths, fences, talus, etc. This process has extensively occurred in coastal areas of the Mediterranean region, where agriculture and industrial-urban uses are in strong competition for natural resources (land, water, etc.).

Desertification processes affect approximately 10% of the total European land. Figure 1 shows the Map of Desertification in Europe. Important areas of Southern and Eastern Europe are affected by desertification, including the following countries: Spain, Greece, Portugal, Italy, Corsica, Croatia, Bosnia-Herzegovina, Serbia-Montenegro, Albania, Malta, Cyprus, Bulgaria, Ukraine and Armenia. These areas have limited freshwater supplies and precipitation varies greatly both spatially and during the year. Besides this seasonal variability, wide fluctuations of rainfall occur over years with frequent and recurrent periods of drought. Furthermore, excessive human pressures leading to desertification on natural resource systems of many of the Mediterranean countries can be attributed to:

- (1) development of national and international programmes and policies for increasing land exploitation and production (e.g. agricultural intensification). The Common Agricultural Policy (CAP) established by the European Economic Community encouraged (before its 1992 reform) European farmers to achieve high production levels of agricultural supplies by providing them financial, technical and training support;

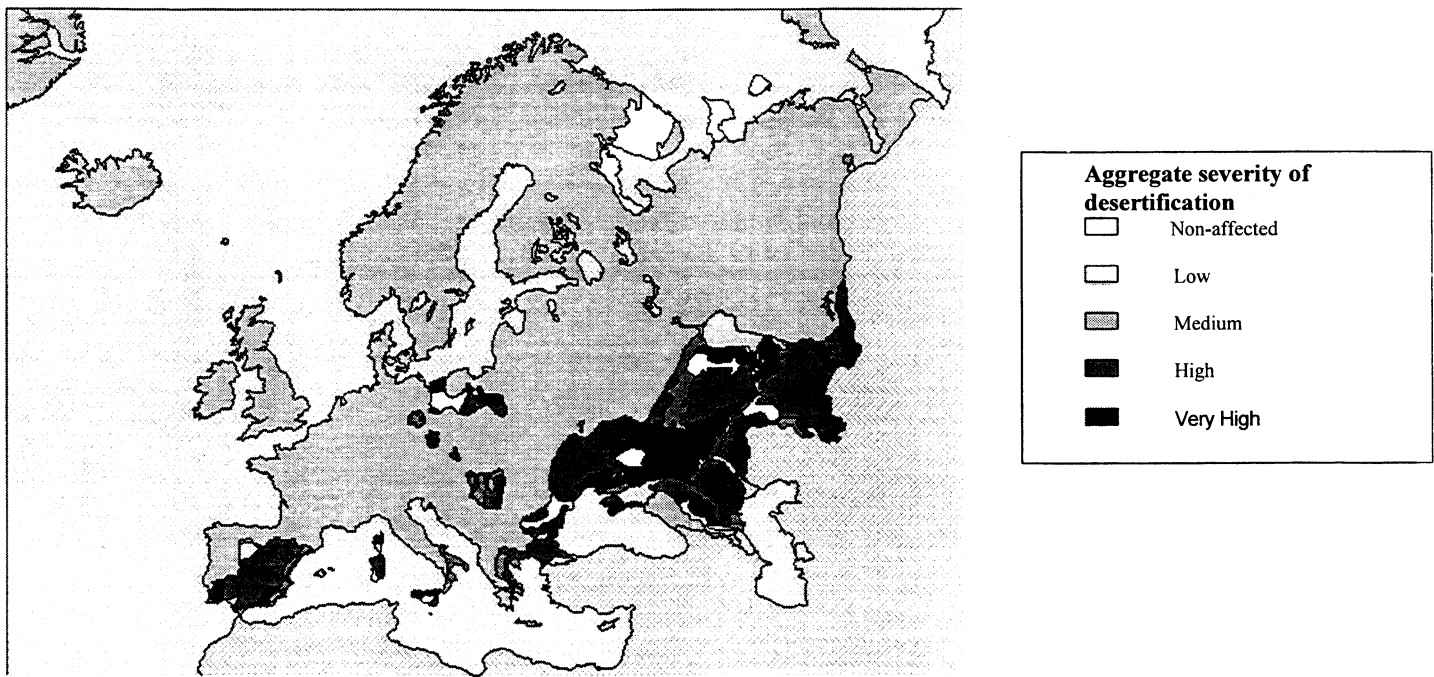


Figure 1. Map of Desertification in Europe Modified from: Oldeman et al.¹²; Armstrong-Brown et al.⁴.



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- (2) socio-political processes (e.g. urban expansion, industrial activities, infrastructure development, tourism expansion, land abandonment, etc.) that influence rural and urban balances;
- (3) increase and movements of population;
- (4) conflicts between land uses for natural resources (e.g. agriculture v forestry occurring inland and agriculture v industrial-urban uses in coastal areas of the Mediterranean region).

An overriding socio-economic issue of desertification can be related to the differential power and access for strategic natural resources that different groups in society have (UNEP¹⁹). The recent reform of the CAP (CEC⁵) can mean an opportunity for the restoration of many areas threatened by desertification processes on the basis of its premises to avoid agriculture in marginal areas and the growing sensibility to environmental issues.

In summary, the main factors and causes of desertification processes at European level are related to biophysical, socio-economic and historical aspects. They are the following: dry climate (e.g. recurrence of droughts, seasonal torrential rainfall), geomorphology favouring soil erosion processes, quantitative and qualitative alterations of the water balance, overexploitation of superficial and underground water resources, inappropriate land use changes, deforestation, increasing forest fires, agricultural intensification, overgrazing, inadequate forest and agricultural practices, urban and industrial expansion, socio-economic factors such as pressure of the population in certain sensitive areas or human abandonment of agricultural marginal land, tourism, market forces affecting agricultural and forestry production, international regulations on trade, etc. A large part of current desertification processes is an inheritance from prior historical actions (immediate and remote).

3 Impacts and consequences

The main effects of desertification processes at European level are the following:

- (1) *Reduction of the capacity of land to buffer the effects of natural and human pressures.* Drylands are usually under a process of



adaptation to harsh ecological conditions. As a consequence, these systems develop an important resilience capacity, which allow them to regenerate after climatic and human impacts occur. However, when degradation processes affect these systems, their resilience is progressively reduced. Some of the consequences are a decrease of the capacity for natural regeneration, alterations on the hydrological regime, loss of productivity and loss of landscape quality.

(2) *Severe soil degradation processes* by erosion, contamination (by heavy metals, pesticides and other organic contaminants, nitrates, phosphates and artificial radionuclides), compaction, loss of organic matter, salinisation/sodication and waterlogging. These soil degradation processes seriously affect the soil functions and capacities to provide goods and services. Such functions and capacities refer to:

- biomass production
- filtering, buffering and transformation
- biological habitat and gene reserve
- foundation or physical medium
- source of raw material
- historical medium.

In Europe about 115 million ha (12% of the total land area) are threatened by water erosion and 42 million ha (4% of the total) by wind erosion (Oldeman et al.¹²). Over 310 000 contaminated sites have been identified in Western Europe (Armstrong-Brown et al.⁴). The land affected by salinisation/alcalinisation processes account for near 4 million ha.

(3) *Reduction of vegetation cover* particularly through land transformation, forest fires and soil degradation. The reduction or loss of vegetation cover is both a consequence and a cause of desertification. This is an important factor (mainly caused by forest fires) triggering the desertification processes in the Mediterranean region. From 1980 to 1990, the total forest area burned in Spain reached the alarming figure of 2.259.530 ha, in Italy reached 1.110.492 ha, in Portugal 888.767 ha, in Greece 515.449 ha, and in France 288.691 ha (Eursotat⁶).

(4) *Quantitative and qualitative depletion of superficial and underground water resources* by over-exploitation. Between 20% and

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60% of the total water supplied in Europe is used for industrial purposes (Groom et al.⁸). Agriculture is also an important user of water in many European countries. About 25% of the total water supplied in Europe are used for agriculture, mainly in irrigated areas. This percentage is increasing in some areas (Groom et al.⁷). These high and increasing consumes of water by human activities (overexploitation) provokes the depletion of water resources. About 60% of the European industrial and urban centres are suffering overexploitation in their aquifers. Salinisation processes seriously affect soils and drinking water in many coastal areas as a consequence of salt-water intrusion caused by overexploitation. This environmental issue is becoming important along the Baltic, the Black Sea and the Mediterranean coasts, specially in the last region due to the increasing development of industrial-urban and tourist areas (Thyssen and Arnell¹⁶).

(5) *Deterioration of the landscape* by the replacement of natural and diverse areas by artificial and uniform areas for cultivation, urbanisation, etc. Unfortunately, it does not exist an European landscape inventory for assessing the dimension, rate and trends of landscape deterioration (Meeus et al.¹¹).

(6) *Loss of biodiversity* directly linked to the loss of habitats due to destruction, modification and fragmentation of ecosystems by intensive farming methods, land urbanisation, etc. The Mediterranean region holds the richest European natural patrimony with more than 25 000 flora species and more than two hundred endemisms. Desertification processes threaten the genetic pool of very interesting indigenous varieties for its adaptation and resistance to climatic variations and disease.

There are also some off-site consequences of desertification. In fact progressive degradation of extensive areas of southern and eastern Europe may involve cross-border alterations affecting countries in more northern latitudes. Amongst other implications, bird migration fluxes and weather parameters of global currents may be affected. Also degraded land may increase downstream flooding, reduce water quality, and provoke siltation of reservoirs and sedimentation in roads and irrigation channels.

4 Perspectives

There are gaps in the existing knowledge on desertification, and there is also a need to develop new research approaches for acquiring more scientific knowledge on the factors, causes and effects of desertification processes. The collection of data and the development of indicators are crucial for a better understanding of the dynamic and complex processes of desertification. Relevant data are required to validate mathematical models, and to update cartographic documents of the areas affected by desertification processes. It is important to develop new methodologies to study the processes of desertification, and to encourage multi-disciplinary research into the phenomena. Research methodology and results should be standardised to ease the transfer of knowledge.

It is necessary to increase scientific information regarding specific Mediterranean and Eastern European country conditions. For this purpose, it should be explored the potentiality of new information technologies (e.g. remote sensing, modelling, indicators, etc.), and transfer the information for better assessment and monitoring the desertification processes. Some of these new technologies includes the integration of georeferenced data base into Geographical Information Systems, which allows an adequate management of the data in order to spatially evaluate the aspects and processes involved in the desertification issue. Similarly sequential remote sensing images allows the appraisal of temporal evolution of the process.

The United Nations Convention to Combat Desertification establishes the global dimension of desertification problems and the possibilities of international collaboration. Moreover, desertification of drylands includes aspects of many disciplines (climate, soil, land use, new technologies...), which also offers great possibilities for international co-operation. Specifically, the Implementation Annex for the Northern Mediterranean Region contains guidelines and arrangements to prepare National Action Programmes and sub-regional, regional and joint action programmes by the affected country parties for the effective implementation of the Convention taking into account the particular environmental conditions of this region. On the basis provided by this Convention, collaboration and co-operation between European organisations and institutions should be established in order to promote initiatives concerning joint programmes, financial aspects and technology transfer for developing pilot research projects of desertification processes.



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The need for integrating socio-economic and environmental factors must be emphasised in developing recommendations aimed at combating desertification processes.

It is important to consider desertification as an issue involving the whole of society. More recognition should be given to the importance and responsibilities of all social sectors involved in the study and control of desertification. Efforts should be made to ensure transfer of ideas and information between these sectors. The scientific community should be encouraged to continue to generate and disseminate information, and to create awareness of the environmental problems associated with land degradation and desertification. Information and environmental friendly methodologies should be provided to people affected by desertification but especially to those at the local level, who are the most directly affected. It is important to develop regulations at the owner level that lead to the restructuring of inadequate agro-forestry, urban and recreation uses of the land.

From the knowledge gained and information generated by scientific research, recommendations/actions proposals for combating desertification should be proposed and implemented. The main strategies of action shall include the following basic principles:

- Integrated land use planning and application of sustainable systems of exploitation of land resources.
- Rational use and protection of soil water resources, vegetation, landscape and ecosystems.

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