**NATO - CCMS and Science Committee Workshop on**

# Desertification in the Mediterranean Region. A Security Issue

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- Museo de las Ciencias “Príncipe Felipe”. Ciudad de las Artes y las Ciencias de Valencia
- Ministerio de Medio Ambiente, Spain.
- Conselleria de Territorio y Vivienda. Generalitat Valenciana
- European Society for Soil Conservation (ESSC)
- Caja de Ahorros del Mediterráneo (CAM)
- Consejo Superior de Investigaciones Científicas (CSIC)
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# OPENING CONFERENCE

# and

# INVITED LECTURES

## Desertification and Security: Perspectives for the Mediterranean Region

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The purpose of this workshop on desertification and security is to bring together both technical experts and decision-makers throughout the Mediterranean Region. It is intended to focus on certain aspects of the environment, especially those leading to land degradation in the arid to semi-arid areas, i.e. desertification. It is also intended to evaluate the apparent consequences of desertification to security, both in regard to social and political instability and also the ability of the environment to produce important ecological goods and services. The workshop is designed to open discussion on the issue of linking security to environmental condition throughout the Mediterranean and to explore the likely regional impacts of security to the social, economical, and political dimensions of human society. The organizers recognize the importance of understanding these linkages in the Mediterranean and the importance of having open discussion which is inclusive to all those who inhabit the region. We hope that this effort represents the beginning of a bigger process intended to bring environmental and societal stabilization to the area and thus will help advance the cause of peace.

This opening session presentation is designed to reflect the wide range of research that has been conducted in the effort to link science with social and environmental security, especially in the Mediterranean Region. Scientists from NATO Member countries, NATO Partner countries, the Mediterranean Dialogue countries, and other international initiatives will gather to discuss a wide range of topics from soil indicators and monitoring techniques, environmental vulnerability, to societal impacts of land degradation. Ultimately, the purpose of this workshop will provide an understanding of both the causes and consequences of desertification on social and environmental security in the hope of developing mitigative measures and policy.

**Desertification - A New Security Challenge for the Mediterranean? Policy agenda for recognising and coping with fatal outcomes of global environmental change and potentially violent societal consequences**

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Desertification (representing soil degradation) is one of three nature-induced (climate change, hydrological cycle) and of three primarily human-induced challenges (population growth, urbanisation and food) of global environmental change. These six components closely interact and contribute to fatal outcomes: primarily to extreme weather events and hydro-meteorological disasters (drought, flash floods, storms) and environmentally-induced migration. These two fatal outcomes may have – in some cases - societal repercussions that may trigger or contribute to domestic, regional or international crises and conflicts and thus they may become an issue of both human, societal, national and international security. To illustrate the causal linkages: for example in Morocco in the 1980s and 1990s, the following chain of events could be observed: severe drought, increase in food prices, hunger riots, general strikes, the police and armed forces interfered to repress these violent upheavals and subsequently hundreds of casualties could be deplored. These cases were not listed as conflicts in the relevant conflict data bases.
The paper is organised in three parts: In the first part, the complex causal interactions among six factors of global environmental change, two fatal outcomes and three societal repercussions: crises, conflicts and conflict avoidance, prevention and resolution will be discussed. In the second part, different security concepts will be reviewed that may be of relevance for dealing with desertification as a security issue. In the third part, possible security relevant pro-active political strategies will be considered, to avoid, and prevent that desertification issues can pose security challenges, and to contribute to a resolution of desertification driven violence.

## Dryland Development, Desertification and Security in the Mediterranean

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Bioclimatically, the Mediterranean basin comprises a transition between southern desert (Saharan-Arabian deserts) and northern non-desert (European woodlands). Using UNEP's aridity classification, the political boundaries of all Mediterranean countries include the whole range of dryland types: from south to north, southern Mediterranean countries which are closer to the Sahara-Arabian deserts than the northern Mediterranean countries, have hyper-arid drylands (true deserts), semi-arid drylands, and dry-subhumid drylands; north Mediterranean countries have semi-arid drylands, dry-subhumid drylands, and non-drylands regions – humid areas. The CCD does not regard hyper-arid drylands as prone to desertification, hence all Mediterranean countries have within their boundaries areas prone to desertification and areas not prone to desertification; in southern Mediterranean countries not prone to desertification are the southern-most and driest regions, and in the northern Mediterranean countries – these are the northern-most and least dry regions. The eastern Mediterranean countries – Israel, Lebanon and Syria combined, present the full south-north gradient of global drylands. The southernmost of the three, Israel, comprises all four dryland types within its boundaries with more than half of its territory prone to desertification, and the analysis of its development, desertification and security can serve as a case study with lessons to the Mediterranean region as a whole.

From the dawn of history the country has been under intensive land use by humans, including pastoralism and cropping. The new Israel viewed its semi-arid areas, most prone to desertification, as a security risk, and set out to settle them mainly through agricultural development, extensive afforestation projects, rehabilitation of vegetation and restoration of water-related ecosystem services. Exploitation and grazing pressure on the dry subhumid scrublands have been reduced, with a fast transition of the vegetation to woodland formation, with restoration of water and soil related ecosystem services.

The sustainability of this agricultural development and its potential to avert salinization were driven by transportation of high-quality irrigation water from dry subhumid-generated resources to drier regions. This has been augmented by water conservation hinged on drip irrigation, and by research and extension services. Dry subhumid areas, arid and hyperarid areas have benefited from the agricultural experience gained in the semiarid region and the infrastructure established to support it. Afforestation practices developed for the dry subhumid areas have “migrated” to semiarid and arid regions. The discovery of geothermal, brackish fossil groundwater and the adaptation of greenhouses to growth houses in dry and hot regions provided farmers with options of intensive cash-crop agriculture and aquaculture – practices that are economic on land use and hence of little if any desertification impact.

During its first decades, Israel rehabilitated many previously desertified areas and prevented further desertification. But in recent decades new desertification is emerging. In the dry subhumid areas there is soil salinization, and increasing impenetrability of dry subhumid woodland and “bush encroachment” leading to degraded range quality and woodland fires leading to soil erosion. In the semiarid areas there is soil erosion of irrigated fields and intensified gully erosion in croplands and rangelands. Salinization of a large scale is expected due to expanding areas of agriculture irrigated with non-desalinated treated wastewater. Thus, rather than generating security problems due to desertification, the attempt to avert security problems by intensified development, eventually lead to desertification.

## Desertification in the Arid and Semiarid Mediterranean Regions. A Food Security Issue

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Agricultural and forest soils in arid and semiarid Mediterranean regions are the most fragile and vulnerable to desertification processes. These processes becomes a food security risk to the quickly increasing population in these areas. Food security is defined as the chance of access for everybody and every time to enough food supply for a healthy and active live. This concept includes the aspects of quantity and quality.

The ability for producing enough quantity and quality of food means the ability, at regional, national and local scale, of enough resources and conditions for producing food. The most important natural resources are soil and water, both of them threatened by degradation (soil erosion, change in the soil physical properties, pollution, vegetation cover loss, salinization, sodification, water scarcity, eutrophization, etc). UNCCD and Mediterranean countries national convention agree that the Mediterranean region is one of the most affected by these degradation processes. While in the north Mediterranean the desertification impacts are more related to environmental problems, in the south Mediterranean countries, desertification is also a very severe social and food security problem. In the future those problems can spread to the whole Mediterranean areas.

The combat against desertification must involve the sustainable use of water ad soil resources and vegetation cover. The task is really urgent and all the governments must be involved. On the other hand the Mediterranean region is one of the more threatened by the climate change, that can speed up the desertification process. Some indicators of the state of desertification are related to environmental, social, economic, technological and political issues.

The aim of the report is summarize the most important factors of desertification in Mediterranean dry areas related to food security problems.

## Border Security and Degradation of the Environment: when "Hard" meets "Soft" Security

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Protection of the borders is a classical case of hard security and it should come as no surprise that NATO, as a provider of hard security, has been increasingly involved in this field in the past years. Border security is an area where challenges may turn into opportunities, since it is not only about protecting oneself from his neighbours, but also about managing borders in co-operation with one's neighbours. NATO's role in the field of border security is therefore two-pronged: to provide expert support in assisting non-NATO countries and, if possible, help in devising regional strategies for border management. When border control takes place along desert areas, an additional challenge emerges as a result of this natural factor. The meeting of the border and the desert is a case of interaction between "hard" security issues interact and "soft" security issues. Such interaction can have at least two directions, the first one being that of border security systems affecting the surrounding environment. Here, the choice of a border security framework entails separate subsets of problems and effects. A strict border security system can improve the sense of security of the populations living in the border areas but it can also perturb established patterns of contact and communication, such as the presence of established trans-border patterns of nomadic behaviour. A loose border security system presents equally problematic aspects, since the sense of insecurity of settled populations is increased by the lack of apparent control and portions of this population might be encouraged to migrate to safer area. It is the usual, agelong dilemma: farmers want fences, herders (and possibly traders) do not. The second kind of interaction is in the way the environment (and in this case, a desert one) affects border. In a desert, borders shift, thereby losing their primary and most substantial role of "sovereignty markers". Also, ensuring border security in desert areas is particularly difficult, for both personnel and materiel (although these difficulties also exist for potential trespassers). What avenues for cooperation can be explored between hard and soft security in this case? An initial answer may be that fighting desertification also protects one's border, by reducing the wearing of human and technical resources and by making the border more clearly identifiable. An effective border management will also reduce the sense of insecurity of local populations and remove one of the possible motives for internal migration. This would also contribute to food security, by avoiding of the abandonment of cultivable lands on the edge of desert zones. Finally, border security should factor human and environmental risks in its strategy. If properly coordinated, "hard" and "soft" security might fruitfully support each other by avoiding that border security creates wastelands that, in the end, would limit the effectiveness of border control.

# KEYNOTES

## The Relevance and Consequences of Mediterranean Desertification Including Security Aspects

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Desertification is a relatively new term but it is also an old issue in the European Mediterranean zone corroborated by the abundance of historical references highlighting the concern of different cultures on important land degradation processes in the region. The perception of this issue has been changing through time with periods of more environmental preoccupation alternating with moment of less attention and sensibility. In the last decades, a conceptual evolution is occurring, passing from a vaguely defined but real problem to a progressive assimilation and clarification of the physical and socio-economical processes involved, their factors, causes and also the impacts and consequences.

In February 1997, come into force the United Nations Convention to Combat Desertification (UNCCD). UNCCD dedicates one of its Annexes to the specific problematic of the affected countries of the Northern Mediterranean region. The other Annexes are respectively dedicated to Africa, Latin America and The Caribbean, and Asia.

The regional Annex for the Mediterranean identifies the particular conditions of the region responsible for the threatening of 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 climatic conditions, Greece has 62%, Portugal 61.5%, Italy has 40% and France 16%), the seasonal droughts, the very high rainfall variability and sudden and high-intensity rainfall.

The main factors and causes of desertification processes acting in Europe operate in different temporal and spatial contexts influencing the course of the natural processes involved in desertification. It is important to identify and characterise the factors and causes acting at each level. At global scale, both natural (mainly atmospheric factors) and socio-economic factors (economical, cultural and political) influence the desertification processes. At regional scale, the factors acting are essentially physiographic, meteorological, economic and cultural aspects, and operate over large areas (e.g. river basins, mountain massifs, coastal zones, etc.). At local scale, the specific physiography, soil types and uses, cultural traditions and land management are relevant factors interfering the desertification processes.

The consequences of Desertification also includes security issues. The concept of Buzan (1998) on Societal Security should be expanded to include direct and indirect consequences of desertification which affect security aspects such as water scarcity, agricultural-food production, increase in the impacts of flooding, extension of forest fires, annual and interannual drought effects, . Also other security aspects affecting Northern Mediterranean countries should be considered such as border security and problems derived from integration and cultural identity of emigrants.

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Environmental and human security remain both evolving and contested concepts. Yet the vulnerability aspects that these security issues present serious long-term challenges to the stability of the Euro-Mediterranean region. This paper argues that there are crucial differences between threats and vulnerabilities, distinguishes between the two, and suggests relevant policy applications for the Euro-Mediterranean. The analysis includes a review for the theoretical models that have been proposed in research. Specifically, this review addresses what have been argued as “trigger mechanisms” that can unleash violent conflict, create socio-economic disparity, and induce long-term insecurity. A number of suggestions for future research are included in lieu of a definitive, overaching conclusion.

## Environmentally Sensitive Areas and Indicators of Desertification

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Desertification is the consequence of a series of important degradation processes in the Mediterranean environments, especially in semi-arid and arid regions, where water is the main limiting factor of land use performance on ecosystems. Among the most important processes of desertification are soil erosion and salinization particularly affecting hilly areas and lowlands, respectively. Various methodologies have been developed in identifying and mapping environmentally sensitive areas (ESAs) to desertification. Studies have been shown that the various types of ESAs have different behaviour on plant growth, crop production, grazing capacity, and soil erosion rates. For example, olive oil or cereal production is decreased as the type of ESA changes from non-threatened to critical areas. Soil erosion measures have been shown that soil erosion rates increased as the sensitivity of the land to desertification increased. Loss in land productivity greatly affects farmer's income and measures applied for protecting the land from further degradation and desertification.

The necessity of elaborating indicators is one of the priorities identified by the United Nations Convention to Combat Desertification (UNCCD). The use of indicators can generally simplify complex processes and provide appropriate tools for combating desertification. Indicators can be classified to those related to the physical environment (soil, vegetation climate), land management (tillage operations, irrigation practices, animal density grazing the land, forest fire protection, erosion measures, etc.), and socio-economics characteristics (farmer age, family size, farm size, subsidies, farmer income, etc.). Indicators can be better used for defining land desertification risk if they are classified according to: (a) the scale of interest (small or large scale), and (b) the land use type. For example rainfall, aridity index, fire risk are more important for small scale studies independently of land use type, while tillage operations, plant cover, soil depth, slope gradient are more important for large scale studies and for specific land use types. Important indicators for defining desertification risk for vineyards are related to land management as well as to land characteristics such as tillage operations, tillage direction, slope gradient, parent material, farm size, soil erosion control measures, etc. Important indicators for pine forested areas are mainly related to land characteristics such as soil depth, slope gradient, slope exposure, aridity index, rainfall, plant cover, etc. Studies, conducted in areas in which the main process of desertification was salinization, showed that important indicators for defining desertification risk were ground water depth, drainage, water quality, frequency of flooding, distance from the seashore, type of land use, rainfall etc.

## Hydrological Approach for Assessing Desertification Processes in the Mediterranean Region

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Land degradation, which affects the conservation of soil and water in adequate places, amounts and qualities, is the main direct cause of desertification. It is related to climate and soil characteristics, but mainly to deforestation and inappropriate use and management of the natural resources soil and water. The main effects are a decrease in water supply, a non sustainable agricultural and food production, and increased risks of catastrophic flooding, sedimentation, landslides, etc. In the medium or long term, the previewed global climatic changes may contribute to accelerate the processes of desertification in the Mediterranean Region, but at short term, land use practices leading to soil degradation processes would increase the negative influence of those changes.

The processes of soil and water degradation, leading to desertification, are strongly linked to unfavourable changes in the hydrological processes responsible for the soil water balance and for the soil moisture regime. These are affected by the climate conditions and variations, and by the changes in the use and management of soil and water resources. In the arid and semiarid Mediterranean climates, the rainfall is highly variable among years and during the year, and usually occurs in erratic storms of short duration and high intensities. This factor increases the risks of land degradation leading to desertification processes. In N Mediterranean countries, agricultural production patterns and practices have been drastically changed in the last decades, emphasizing labour-substituting technologies in some cases, with abandon of traditional soil and water conservation practices, and leading to the abandonment of agricultural lands in others. By contrast, in most of the S Mediterranean countries, population growth and lack of resources have obliged to intensify the use of marginal lands without appropriate conservation practices. Both situations frequently lead to accelerated land degradation and desertification processes, although in N Mediterranean countries, if resources are available, these processes and effects are usually masked by technological external inputs of energy, irrigation water, nutrients, and other control measures. Any break in these artificial measures, generally causes a complete loss of productivity and leads to accelerated desertification processes.

Hydrological approaches would be essential to identify and assess the causes and processes of desertification. The evaluation of the hydrological processes, under different scenarios of changing climate, soil properties, and land use and management, with flexible simulation models based on those processes, may help to predict and to identify the biophysical causes of desertification at local, national and regional levels. This is a required previous step for a rational land use planning, and for the selection and development of short and long term strategies and technologies to reduce or to control land degradation processes leading to desertification, and to the related social economic and security problems. There is proposed an integrated framework for the development of this kind of approach, with examples of potential application under Mediterranean conditions.

## The Use of Alternative Futures in a Strategy to Assess the likelihood of Increased Land Degradation and Subsequent Political Instability

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As stated by the United Nations Convention to Combat Desertification (UNCCD), desertification or land degradation is at the root of political and socio-economic problems and poses a threat to the environmental equilibrium in affected regions. That desertification and political instability are interlinked should not be a surprise; the UN states that half of the 50 armed conflicts in 1994 had environmental causal factors characteristic of drylands (i.e., land degradation). The cause and effect factors are clear. One example cited states that the land's loss of productivity exacerbates poverty in the drylands, forcing its farmers to seek a way of living in more fertile lands or cities. In fact, 135 million people- the equivalent to the population of Germany and France combined - are at risk of being displaced as a consequence of desertification.

This paper suggests a technique, alternative futures analysis, to model the likelihood of future land uses in a given region undergoing desertification or at great risk to desertification and to develop an understanding of the risk to political instability coming from each of the alternatives. Such a strategy would help local, national and regional land managers, working with their constituent stakeholders to mitigate such effects.

The physical, biological, and social causes of desertification which lead to grave human impacts are interlinked with significant feedback mechanisms. Soil salinization, for example, may result from unsustainable irrigation practices. Changes of vegetation from perennial grasses to shrubs and to annual grasses and forbs might result from overgrazing. Increases in poverty and human out migration might result from declining agricultural productivity caused by salinization and overgrazing.

Because poverty forces the people who depend on land for their livelihoods to overexploit the land for food, energy, housing and source of income, desertification can be seen as both the cause and consequence of poverty. Any effective mitigation strategy must address poverty at its very center. It must take into account the social structures and land ownership as well as pay proper attention to education, training and communications in order to provide the fully integrated approach which alone can effectively combat desertification.

Seeking solutions to such complex problems requires appropriate technologies and common sense. Alternative futures analysis provides a technique for illustrating possible conflicts as well as its causes and potential solutions. We finally suggest a framework for a pilot project employing this technique.

# INVITED PRESENTATIONS

## The Environment and Security Initiative: Transforming Risks into Opportunities for Co-operation

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Environmental changes, increasing scarcity of natural resources or rising opportunities for rent-seeking behaviour, play a *decisive* role in the emergence of conflicts – namely by decisively accelerating or triggering social problems. As yet, the causative capacity of environmental stress or competition for control as a conflict accelerating or triggering factor can only be ascertained in individual case studies.

Environmentally-induced conflicts generally operate below the violence threshold, their volatility is thus less visible at first. They are based on societal and economic problems (including weak or absent governance structures) or non-sustainable human-environment relations in general, making them all the more complex.

Environmentally-induced conflicts arise mainly in regions with emerging economies and societies undergoing transformation, although in varying manifestations. They are not the result of singular influencing factors but the outcome of (complex) societal aberrations.

Despite the complexity of the sources of conflict, the environmental components provide a potential for preventive measures. Global environmental policy, in particular, relies on the principles of co-operation and reconciliation of interests. Using this experience, environmental policy instruments or negotiations on environmental problems can be used to peacefully resolve conflicts in which a peaceful solution to other, perhaps more decisive sources of conflict is not possible.

The **OSCE/UNDP/UNEP Environment and Security Initiative** intends to provide a framework for co-operation on environmental issues across borders and promote peace and stability through environmental co-operation and sustainable development. It builds on the combined strength of the three lead organisations' expertise, experience and field presence. The project concept is designed to provide a coherent structure for three key areas of activity: vulnerability assessment and monitoring of environment and security linkages; capacity building and institutional development; and policy development, implementation and advocacy.

## Remote Sensing of Long Term Changes for Desertification Monitoring in Northern Africa

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The southern part of the Mediterranean region is by far the most threatened by desertification, and monitoring this phenomenon requires to watch very larges areas. Remote sensing techniques have logically been seen as the tool to achieve such an objective. However satellite images are just 'snapshots' of the land surface at a given moment, and their interpretation requires a fair knowledge of what is on the ground.
An approach integrating all available data on the land surface of test areas has been developed within the frame of euro-Mediterranean research programmes involving four countries of northern Africa (e.g. the CAMELEO project). It has been based on the identification of ground indicators of local ecological changes (degraded, stable, restored condition...), the determination of those that can be remotely sensed (using field measurements of surface reflectance), the selection of the most adequate high resolution satellite data, the refinement and the design of processing algorithms in close connection to physical considerations and desired information outputs. This «bottom-up » approach has been applied to historical records of data in an attempt to identify long-term changes and to assess desertification trends.
Among the most important results, the following ones will be reviewed :

- The above ground biomass is usually low in the studied region and not detected with classical remote sensing approaches (NDVI), green vegetation changes are sporadic and mainly driven by meteorological events
- The non-vegetated component of the land surface (i.e. soils) is dominant on the ground and consequently in the signal measured by satellites. As a result specific land degradation phenomena can be detected through soil surface changes in color and/or composition
- Long time series of high resolution images need to be analyzed to detect long term changes, this implies using different satellites (older and newer ones) and their delicate inter-calibration (with pseudo-invariant features).
- Trends can be reliably detected only when desertification is associated with significant soil surface changes such as sand movement.

Consequences for satellite-based desertification monitoring programmes are discussed in the perspective of integrating data from the most recent and forthcoming Earth Observation programmes.

# Mediterranean Forest for People without Deforestation in North Africa

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There are several European groups interested in conserving extensive agrosilvopastoral systems in Mediterranean basin countries. However, there are not government measures directly applied to avoid resources base degradation and destruction from market trends in Mediterranean agrosilvopastoral systems in North Africa. Overgrazing, overpruning and forestland conversion in croplands or infrastructures create difficulties for maintaining soil fertility, biodiversity conservation and labour income in Mediterranean agrosilvopastoral systems. During the last two decades have been in North Africa a huge degradation and deforestation rates of matured Mediterranean forests. To offset the oak destructions in North Africa a new crops investment plan is the priority for maintaining natural resources and environmental values. This desire requires radical changes in governments cooperation between the two parts of Mediterranean agrosilvopastoral systems, that is, the European Commission and Morocco, Algeria and Tunisia.

## Participatory Experiences for the Evaluation and Mitigation of Desertification in the Sicilian Region

**Maurizio Sciortino**

Sicily is one of the Southern Italian region most affected by drought and desertification. In the framework of the collaboration undergoing with the Ministry of Environment and Protection of Territory, (MATT), The Italian Agency for New Technologies, Energies and Environment (ENEA) has carried out a pilot-study in this region and in particular in the Agrigento Province, aimed at:

1. Evaluating intensity and extension of drought and desertification. On the basis of existing data and observations the ESA (Environmentally Sensitive Areas) Index, proposed by the European project MEDALUS (Mediterranean Desertification and Land Use), has been applied. An integrated assessment of Climate, Soil, Vegetation and Land Management has been produced by GIS elaboration. The results show: 6.9% of the Sicily Region has a high sensitivity to desertification , 46.5% a medium sensitivity, 32.5% a low sensitivity, 7.2% no sensitivity. The areas most vulnerable to water erosion are the inner provinces of Caltanissetta, Enna and Catania. Further work should be carried out to include in the assessment the areas affected by soil and water salinization.
2. Evaluating the socio-economic dimension of the phenomenon. At this aim, participatory activities have been also carried out, by the European Awareness Workshop Scenario (EAWS) methodology in the municipalities of Licata and Cammarata in the Agrigento Province. Both EASW experiences have recorded a vivid participation of the local inhabitants and decision makers. Viable solutions and proposals tailored for the local situations have been identified in a democratic discussion among the different stakeholders. Local authorities endorsed the results achieved as a basis for the successful implementation of future initiatives to combat drought and desertification at local level.

## The fight against desertification in the Mediterranean and the Spanish Co-operation of Development: The Azahar Programme

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The Azahar Programme establishes a framework of co-ordination for all the public and private bodies involved in Spanish development co-operation, with the aim of generating a real impact on human development in Mediterranean Basin countries, making fight against poverty and the development of societies in the coastal countries compatible with environmental protection and the preservation of their natural resources. As well as the Ministry of Foreign Affairs, through the Spanish Agency for International Co-operation, the Ministries of Agriculture, Fisheries and Food, the Environment, Finance and Science and Technology, along with the Autonomous Communities of Catalonia, Asturias, Andalusia, Murcia, Valencia, Castile-La Mancha, the Canary Islands, Navarre, Madrid and the Balearic Islands are involved in the Azahar Programme, along with civil society through NGO's, academic and research institutions, and business associations. Azahar is aimed at three large sub-regions of the Mediterranean area: Magreb, the Middle East and the South East of Europe, and within these, it gives preference to countries considered priorities, as well as special preference within the Master Plan 2001-2004 and the Annual Plans of Spanish Co-operation. These countries include Algeria, Morocco, Mauritania and Tunisia in Magreb; Egypt, Jordan, the Lebanon and the Palestinian Territories in the Middle East, and Albania, Bosnia and Herzegovina and Serbia and Montenegro in South East Europe. Seven areas of action have been defined in the Azahar Programme that seek to provide an effective response to the main environmental problems faced by countries in the south and east of the Mediterranean basin, in which Spain has extensive experience and a high level of knowledge, allowing it to establish effective technological transfer processes with these countries. The areas of action are as follows: sustainable water management, renewable energies and the efficient use of energy, land preservation, sustainable production, sustainable tourism, environmental planning and management and environmental sanitation. The Azahar Programme has defined priority areas of action within the Programme's seven areas in order to promote a greater consistency in the activities of the participants as a whole. The priority areas of action over the next few years are: Integral water management through Basin groups and user organisations; Development of solar and wind energies; Integral rural development projects focused on the efficient and diversified management of natural resources; Local Agendas 21; Management of protected areas whose nature, landscape or heritage make them areas of interest, promoting their sustainable use by the local population; Environmental quality in industry; Managing solid urban waste; Treating urban wastewater through the use of unconventional technologies. The projects that make up the Azahar Programme should respond simultaneously to the following three basic principles: the development of local populations and the improvement of their living conditions within the framework of the Spanish policy of international co-operation for development; environmental protection and the preservation of natural resources, and organisational and institutional strengthening, promoting local planning and management capabilities. They should also involve one of the Programme's seven areas of action and meet the guidelines established by the Aid for Development Committee in terms of aid for the environment. At the present time, fifteen Spanish administrations (at national and regional level) are executing 88 development projects within the framework of Azahar Programme in the field, with an total cost of 16.731.508,51 euros only in 2002. With respect to the distribution by sectors, most of activities (63) are related to combat desertification, through the implementation of projects on land preservation, renewable energies, sustainable water management and sustainable production. In addition to carrying out sustainable development projects in the different beneficiary countries, Azahar includes an important programme of advanced seminars in order to achieve the Programme's scheduled objectives. In 2002 and 2003 twenty advanced seminars have taken place with the participation of 450 experts and professionals from the Mediterranean countries, mostly from the public administration, who dealt with technical issues related to Azahar Programme. Another 10 seminars will be organised for 2004. These specialist seminars, whose content is highly practical and responds to local demands and the context of the countries of the south and east Mediterranean, will promote the active participation of attendees, combining theoretical aspects with case studies and the exchange of experiences through the organisation of round tables and discussions.

# TOPIC 1:
# CONSEQUENCES AND IMPLICATIONS OF MEDITERRANEAN DESERTIFICATION. SOUTHERN AND NORTHERN PERSPECTIVES

# COUNTRY REPORTS

## Problématique de la désertification en Algérie: Etat et Mesures de Lutte

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La problématique de la désertification en Algérie se pose en terme de développement. Au vu du constat qui est fait en matière de dégradation des ressources naturelles (sols , végétation, eau), il apparaît que les principales causes liées à ce phénomène sont notamment d'ordre anthropique . Si les régions du Sud Algérien qui englobent une grande superficie du Sahara sont déjà désertifiées, ce phénomène apparaît également au niveau des régions du Nord et notamment au niveau de la steppe où déjà plus de la moitié de sa surface (20 millions d'hectares) est menacée par la désertification.
Des efforts ont été entrepris depuis 1971 pour enrayer ce phénomène à travers le projet «Barrage vert» réalisé par les jeunes du Service nationale militaire, mais qui restent très insuffisants.
L'accélération du processus de désertification a entraînée des impacts négatifs tant sur le plan économique que social et qui se sont traduits par:

- la réduction des possibilités fourragères
- la précarité de l'élevage
- la rupture du système d'organisation pastorale
- l'ensablement des infrastructures de communication et l'enclavement de certaines agglomérations.

Dans le cadre de la mise en œuvre de la convention internationale sur la lutte contre la désertification, un plan national d'action a été élaboré et devra être valider prochainement.
Outre les techniques classiques de lutte contre la désertification (reboisement, correction torrentielle, amélioration foncière, fixation de dunes etc…),d'autres techniques sont également introduites, notamment en matière d'évaluation du phénomène à travers l'utilisation de la télédétection et d'approche à travers la mise en place de schéma régionaux de développement
La lutte contre la désertification est également la lutte contre la pauvreté et la famine et par conséquent c'est la lutte contre l'insécurité et l'atténuation des conflits sociaux.

## Security Impacts of Desertification in Egypt

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The Arab Republic of Egypt is situated in the north-eastern corner of Africa, lying within the great Sahara desert.

Egypt has a total area of one million square kilometers. It can be divided into four ecological regions. Barren deserts represent more than 90% of the country's land area. Three ecological zones out of the four have a very weak ecological structure. The fourth one, the "Nile valley" is moderate. Detrimental pressure on environmental inputs are strongly reflected in the process of desertification. This, in turn, has social, economic and political consequences that affect security.

The Eastern part of Egypt consists of four governorates, including "Southern Sinai" which occupies 18% of Egypt's total area. This governorate acutely lacks in natural resources. The local community is mainly composed of poor Bedouin tribes. Poverty is compelling them to move frequently for animal grazing, making additional stress on the already weak environmental structure of the region. The frequent movement of Bedouin populations is accompanied in many cases with the spread of disease and increased rates of crime.

The Western part of Egypt occupies 36 % of Egypt's total area. It constitutes one single governorate: "The New Valley". It significantly lacks in natural resources including human resources -except in oases that are scattered in the region. Inland immigration to the Western Desert from the Nile Valley where the population stress is very high and poverty is widespread, represent a good "theoretical" solution to potential social and economic problems. Yet, as a result, new kinds of crimes are being introduced along the immigration pathway. This creates additional security problems in this relatively virgin area.

The national action program to combat desertification (NAP) takes into consideration the abovementioned factors. In order to better deal with potential security problems, it includes two development projects that aim at decreasing inland immigration and enhance Bedouin settlement.

## The Challenges of Land and Water Resources Degradation in Jordan: Diagnosis and Solutions

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Desertification is the degradation of drylands. The process involves loss of complexity of biological and/or economic productivity of crop-, range- or wood-lands. The arid and semi-arid lands of Jordan are sensitive to human interference that resulted in a severe depletion of its natural resources, especially excessive soil erosion following shallow rainstorm events. Such a fragile ecosystem has also been manifested by non sustainable land use patterns and poor vegetative cover of the rangeland and the remaining forest batchs. Therefore, most of the economic activities take place on 10% of the land area which receives more than 200 mm of annual rainfall. Competition between different user groups for these lands is therefore intense. Factors contributing to land degradation are these of overgrazing practices, inappropriate agricultural and irrigation techniques, the marginalizing of lands, poor socio-economic conditions, high population growth rate and weak institutional capacities. Rangelands are deteriorating at an accelerated rate due to widespread overgrazing, uncontrolled herd movements, firewood collection, unsuitable cultivation practices, and persisted periodic droughts, all of which worsen ecological conditions. Cultivation of marginal lands, and unsound practices such as ploughing down slopes, and use of heavy farm machinery have accelerated rate of soil erosion and lowered land productivity. Urbanisation is also steadily encroaching onto good quality agricultural land in the higher rainfall areas of the Jordanian highlands, reducing the traditional production areas of food crops such as wheat and barley

Jordan suffers from a scarcity of water resources, which is compounded by poor management of existing supplies. Pumping of aquifers for irrigation and municipal uses has been exceeding their renewable safe yield. No serious attempts have been committed to improve natural recharge into these aquifers, encourage water harvesting practices or adopt water conservation measures, especially in irrigation. The current demand for municipal, industrial and agricultural water in Jordan exceeds sustainable water supply and the problem is further aggravated in dry winters like the case in the 1998/99 season. Irrigation has made crop production possible in many areas but the long-term effects of fertilizers and pesticides on water quality, as well as on soil salinity, have been given only limited attention. Furthermore, poor wastewater treatment, and industrial pollution have compounded the problem. Current and future deterioration of water quality will have marked effects on degradation of the land. Socio-economic factors contribute negatively to desertification and to efforts to combat its effects, poverty constitutes a vicious circle linking deterioration of natural resources to deterioration of livelihoods. Also, the population increase is adding an additional pressure to land and water resources, as people need to encroach further on fragile soils, sparse vegetation and limited water resources. The institutional capabilities of the Government as well as the existing legislation and policies need to address the serious degradation of its agricultural, range and forest lands, and aim to improve land capabilities and increase production for communities will require support. Financial and technical support will be required to introduce new agricultural products, agricultural techniques, water harvesting techniques that will result in increased land productivity, yet with less pressure on fertility and water resources. Also, communities will be encouraged to engage in diversified economic activities that will alleviate pressure on natural resources. This may be accomplished through the adoption of participatory approaches that raise awareness of local communities to threats of desertification and to strengthen local institutions, which are essential for reversing desertification and environmental degradation, especially considering Jordan's transition economy.

## Combating Desertification in Israel

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The total area of arable land in Israel has increased from 1,600 square kilometers in 1948 to approximately 4,200 square kilometers in 2001. Irrigated land has increased from 300 square kilometers in 1948 to 1,866 square kilometers in 2001. Water scarcity is a main limiting factor in Israeli agriculture. Annual rainfall ranges from about 800 mm in the north to 25 mm in the south of the country. Agriculture is the number one factor in the protection of open space and prevention of desertification and serves as a sink for the waste produced in the urban sector, whether effluents, sewage sludge or compost.

The combination of severe water shortage, densely populated urban areas and highly intensive irrigated agriculture, makes it essential that Israel put wastewater treatment and reuse high on its list of national priorities. In fact, national policy calls for the gradual replacement of freshwater allocations to agriculture by reclaimed effluents. Currently about 65% (nearly 290 million cubic meters) of the wastewater produced in Israel is reclaimed for agricultural reuse. A new standard for unlimited use of effluents is being formulated. The standard, which relates to 38 parameters, takes account of public health, soil, hydrological and flora considerations. As a result Israel will be able to exchange nearly 50% of the fresh water (about 500 million cubic meters) which was taken away from agriculture to serve the municipal and industrial sectors. The objective is to treat 100% of the country's wastewater to a level enabling unrestricted irrigation by the year 2010 in accordance with soil sensitivity and without risk to soil and water sources.

Sewage sludge is regarded as a valuable resource for fertilization and soil improvement of marginal and degraded soils. However its use should be allowed only following appropriate treatment to reduce pathogens and vectors and to control and reduce heavy metal concentrations. Guidelines and draft regulations that require wastewater treatment plants to stabilize and treat the sludge they generate as a condition for agricultural use or soil improvement have been formulated. The draft regulations establish maximum permitted levels for heavy metal and pathogen concentrations in sludge designated for agricultural use, define specific uses for class A and B biosolids, and set limitations on areas of sludge use. The aim is to prevent damage to agricultural crops, public health, soil and groundwater. Currently 45% (50,000 dry tons) of the country sewage sludge is being used successfully in agriculture, mainly in non-irrigated wheat crops with an average 25% increase in yield.

Israel's success in its constant struggle to combat desertification during the last 54 years is largely attributed to its agricultural practices. Israel's agriculture is characterized by a high technological level and is based on drip irrigation systems, automatic and controlled mechanization, and high quality seeds and crops. Wastewater treatment and reclamation, floodwater storage, run-off harvesting, and dryland afforestation complement these techniques in the struggle against desertification.

# L'Expérience Tunisienne de Développement dans les Zones Désertiques. Le Cas du Projet de RJIM MAATOUG

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En 1972, des prospections pétrolières dans la région saharienne de Rjim Maâtoug ont abouti à la découverte d'une nappe d'eau importante inexploitée. Le Gouvernement tunisien, soucieux d'exploiter toutes les ressources naturelles nationales pour le développement du pays, a décidé d'utiliser cette réserve d'eau pour la mise en valeur de la région.
Des études techniques ont été menées pour fixer l'importance et la durabilité de la nappe avant d'entreprendre l'étude de faisabilité du projet.
En 1977, un premier forage a été creusé. En 1984: Après avoir obtenu des résultats encourageants permettant l'utilisation de la nappe, l'Etat a distribué 200 lots de terrain plantés en palmiers dattiers à Rjim Maâtoug et 100 ha a Matrouha. Un premier noyau de 300 agriculteurs sont déjà installés dans la région.
Cette phase expérimentale a été concluante, et a incité les responsables à mener une étude approfondie pour la mise en valeur de 2500 ha. La capacité de la réserve d'eau permet l'exploitation de 2000 litres par seconde en artésien jusqu'à l'an 2020.Un plan directeur des eaux du sud a été élaboré en conséquence pour permettre une exploitation rationnelle de l'eau.
En 1987, une étude technique très approfondie a été menée et l'équipe chargée de cette étude s'est fixée des buts à atteindre à savoir socio-économique géo-écologique et stratégique. Voilà des buts qui répondent aux problèmes d'actualité.
En 1989, les pays de l'Union Européenne ont accordé au projet une aide financière représentant un peu plus de deux tiers du financement et, à la fin de la même année le projet a vu le jour. Un office a été créé pour la circonstance et s'est vu attribuer la noble mission de la réalisation de ce projet dont le coup d'envoi a été donné en janvier 1990 pour l'exécution d'une première tranche de 1152 ha à planter en 6 ans. Les lots plantés sont distribués aux agriculteurs à raison de 1,5 ha après leur entrée en production (5ème année après la plantation).
Un logement rural est également octroyé à l'agriculteur pour lui permettre de se fixer non loin de son lot. Actuellement toute la première tranche a été réalisée .Les lots plantés en 1990 ont été distribués. Le village conçu pour les agriculteurs répond à toutes les exigences de la vie actuelle (Création de l'école, le dispensaire, la route goudronnée, le réseau électrique et le téléphone rural).
Le projet n'est pas encore achevé. Il reste à réaliser une 2ème tranche d'une superficie de 1008 ha. Ainsi, à la fin de l'an 2009, une véritable barrière verte sera dressée au sud-est de chott Djérid pour empêcher le Grand Erg Oriental de progresser et finalement Rjim Maâtoug aura gagné la bataille de lutte contre la désertification et ce par la sédentarisation de nomades reconvertis en agriculteurs convaincus que le Sahara peut enfin produire et contribuer au développement économique du pays, surtout lorsque les 2500 ha entrent en pleine production et fourniront 20.000 tonnes de dattes «Deglet Nour» qui seront injectés dans les marchés locaux et étrangers.

## Land Degradation and Desertification in Turkey

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The total arable land in Turkey is 28.054.000 ha. However, the prime soils cover only 17.5% of the total land surface and the productivity of the remaining soils is mainly limited by topography, depleted organic matter and high clay contents.

The long standing deforestation, unsuitable tillage and irrigation management have induced the rate of erosion since historical periods. The majority of the country s soils (76.5%) are prone to erosion risk due to the dominant steep slopes (>6%),and 72% of the soils are more or less affected from water and wind erosion (CCD-TURKEY,2003).Soil sealing and extraction of raw materials together with overuse of fertilizers and irrigation have led to the improper use of traditional environmental friendly agroscape (agroecosystem), thus constantly degrading the soils of the country. Secondary salinity builds up in the primary saline zones as well as the fertile alluvial plains of Turkey, which are actually the gene zones of many crops particularly cereals, legumes and halophytes, pointing out to the reality that irrigation management plans should not only be based on the concept of conventional cash crop production but also for the crops present on the indigenous agroscapes. This necessitates the incorporation of the halophyte production in the central Anatolian steppes and the olive/carob/vine production in the semi-arid Mediterranean karstic region together with the south east Anatolian calcrete agroscapes. This paradigm in sustainable land use management aims to increase the welfare of the urban people and decrease the threat of excess water use in fragile steppe, karstic and calcrete topographies, which are also the carbon pools of the world. Hence, the concept of agroscapes based on landuse assessment should primarily be considered in the development of sustainable land management strategies particularly with the incorporation of indigenous environmental friendly technical knowledge to combat land degradation and desertification.

The high population increase in the urban regions and conversely the decrease in the rural, cause the intensive use of arable land around the former inducing desertification. According to the census of 2000, 40% of the country's population lives in rural areas (23.797.653 out of the total 67.803.927) with an average of 1.21ha/man arable land, mostly allocated for cereal production (country average ~2000kg/ha). This is equivalent to a low net income rate, which results to migration from the rural areas to urban, particularly from the east of the country to the west. The Government Statistics Institute (2003) data reveals that from 1990 to 2000, the urban population increased by 30%, ie from 33.656.275 to 44.006.274, whereas the rural increased at a much lower rate (4.3%). This data reveals the pressure of both natural and human induced factors on soils and land urgently in need of sustainable land management policies along with legislations, since, the rate of quality loss of land and soil, ie desertification in the coming decades will ultimately be the common jeopardy in the country.

## Level of Realisation of the National Action Plan (PAN) in Italy.

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From the foundation of the of the First National Committee to combat Drought and Desertification, with the Decree 26/9/1997, Italy has presented only one PAN with the Resolution CIPE 21 December 1999.
Inside the Plan there are mainly the guide lines and the method indications, based on what is foreseen from the Art.10 of the ONU Convention.
From the month of September 2003 is active the new CNLSD that has to take over the burden of putting into practice the PAN and to update to the actual problems of the Italian territory.
For this reason we have thought to present in Rome the 20th of November 2003 in an International Meeting the main lines of realisation of the PAN.
The main properties can be summarise in this way:

- formalisation of a stable relationship with the political world, because it is the responsible to decide for the fighting-activity against drought and desertification to be realised in the country;
- offer to the Regions, to the Basin Authorities and to the local operators of the experience and the results of the European scientific research regarding the drought and desertification;
- offer to the Regions of the technical and operative availability of Organisations that, institutionally, work and make monitoring activities on the Italian territory: ENEA, INEA, APAT. It will be drafted a protocol of an institutional agreement, useful both for the drafting of the projects, and for their realisations;
- using, through a specific project, of a calculation centre of excellence to manage and to elaborate the foreseen data from the Resolution CIPE of 1999. It will be implemented an integrate system to elaborate the data from the Italian Regions, following procedures of consolidate calculation, but in an unitary way with the relative georeferenced map-making and the ortophotos;
- at last we will search to activate the participation of the entrepreneurial world, which is responsible to realise the interventions of prevention and mitigation of the drought and desertification.

## Desertification, Territory and People

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The concept of desertification is associated with land degradation, water scarcity, and for some with soil erosion and loss of productivity due to human causes and climatic change in arid to sub-humid climates. However, despite the definition produced by the UNCCD is generally not questioned, there is not a common agreement in its interpretation nor about the concepts behind it. In Portugal a wider approach is adopted by considering that desertification do not affect only the soil and water resources but the territory with consequences on all activities and not only agriculture. Therefore, desertification impacts on the societies, urban, rural and agricultural, living in relatively vast territories, where the degradation of natural resources and the pressure on the use of water and land has created or is creating adverse conditions for the people living in such environments.

In Portugal, the public opinion commonly associates the term desertification to loss of population, fact that expresses well the dynamics of the territories affected by degradation, lack of opportunities for development, and lack of jobs for the younger generation. When the National Action Programme to Combat Desertification (NAPCD) was established among 79 actions proposed only 5 related to soil, all other related with living conditions of people, economic activities and water, i.e. the term land in the UNCCD definition was largely assumed as territory. When pilot areas were established in several locations along the country, workshops were organized with stakeholders and the population where the signs of desertification were identified: first came the economic factors, then loss of population, erosion, water scarcity, degradation of vegetation cover, and land abandonment.

In developed countries such as those of northern Mediterranean that are part of Annex IV of CCD, the consequences of desertification in terms of reducing the capability of land to produce food are not significant. In fact those consequences add to those of the Common Agricultural Policy relative to reduce agricultural land and are difficult to be distinguished from the later. However, changes in land use that produce a decrease in agricultural activities have enormous impacts in less favoured regions. Migration from these regions to urban areas lead to land abandonment and policies favouring a decrease in agricultural areas favour emigration and aging of populations. Nowadays, in large areas, the remaining population is not anymore sufficient either to keep a demographic balance, either to maintain social and economic activities at a minimum standard level, including schools, health services and market of essential goods. The conditions for making people to live at a minimum standard retrograde to non-return conditions, thus creating enormous unbalances among regions of emigration and immigration. Therefore development, progress goes to regions where people is attracted while the others recede both in terms of population and chances for development.

In the framework of DISMED, a study on several indicators of physical, climatic, economic and social nature has been performed. Maps relative to these indicators were created and later superimposed to identify the areas prone to desertification. Results indicate that socio-economic indicators are relevant for defining the areas prone to desertification, in agreement with opinion expressed by stakeholders and population in pilot areas.

Great forest fires occurred this year throughout the country. However these fires occurred dominantly where the degradation of the territory and of the living conditions of the people are evident. Land abandonment and afforestation of the traditional agricultural areas near to the small rural towns have created conditions not only to increase fire propagation but also where populations were endangered.

Desertification is also a question of security: the regions that are a continuous source of immigration have nowadays problems similar to those faced centuries ago when the territory was recently conquered: there is a lack of population that assures the occupation of the territory. The consequences of such a situation are yet not known.

In degraded regions prone to desertification, the response of populations to any incentive is limited. This fact creates increased difficulties to develop and implement measures that could fight both the causes and the consequences of desertification. New approaches to the problem are required. Particularly, it is a must to make understand to responsible of governmental policies that fighting desertification is a matter involving innovative economic and social measures in addition to those relative to environment. It is the people and the territory that must be the target of such policies.

# ORAL PRESENTATIONS

## Fostering Networking and Exchange of Information in the Mediterranean Region: The MEDCOASTLAND Thematic Network

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Land degradation and desertification represents one of the most striking sets of processes affecting the Mediterranean Region causing persistent deterioration of the physical, chemical and biological properties of the land components, especially the soil. Land degradation, then, results in loss of overall *productivity*, which in turn impairs sustainable development in the region. This is particularly evident in the coastal areas of the Southern Mediterranean, with entire landscapes no longer able to maintain productive functions.

Although many EU-funded research projects have succeeded in collecting information and understanding physical processes of land degradation, their impact on the territory has been rather poor partly due to the still existing communication gaps between institutions/scientists and land users. The lack of networking among different Mediterranean countries and the lack of integration between physically driven and income-product generating criteria are proving to further aggravate the situation.

In addition, a real participatory approach involving scientists, decision-makers, and local communities is still missing. In order to fill these gaps and to foster exchange of information in the region through the establishment of a task force involved in combating land degradation, the MEDCOASTLAND Thematic Network was set up. The main objective of the Network is to contribute to the sustainable development, planning and management of natural resources in the Mediterranean region through dissemination of existing research results deriving from previous projects. The dissemination is done via the Internet and five workshops, plus one international conference. These events will be organised over the period 2002-2006.

There are 13 countries (from south Europe, North Africa, Middle and Near East) participating in the Network making a total of 36 partners, of whom 18 are research and educational institutions, 9 represent decision makers and the remaining 9 partners are farmer's associations and NGOs. The Mediterranean Agronomic Institute of Bari, in Italy is coordinating the project.

The project will address not only the physical aspects of land degradation. Specific Work Packages deal with income-generating aspects of soil conservation, including socio-economic considerations; detailed analyses of participatory approaches (top-down and bottom-up) involving decision-makers and local farming communities; development of national and regional guidelines to promote sustainable land management; and finally setting the floor for continuous cooperation in the region, even after the life span of the project.

Additional information could be retrieved by visiting the web page: http://medcoastland.iamb.it

## Desertification in the Mediterranean Region's Developed Countries: Andalusian Anti-Desertification Strategy

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More than 3.600 hectares in the world and 99 countries of every continent are affected by desertification, of which 18 are developed countries and the remaining 81 are Least Developed Countries. Causes of and solutions for desertification are very different between Developed Countries and Least Developed Countries.
Andalusia, in Spain, a Mediterranean developed country, is a region of 87.597 $km^2$ with a family income of 7536 Euros per year. Despite this, its Mediterranean climate, its rough topography and the fragility of its soils have benefited the advance of desertification in the region.
There are five Andalusian landscapes related to desertification:

- Mountainous and forest inlands, where forestal fires benefit erosion processes
- Tourist and very populated coast, where overexploitation of water-bearing and salinization benefit desertification progress
- Inland farming soils, where inadequate agricultural activities and the abuse of pesticides and fertilizers benefit erosion processes
- Left cultures, where farmers abandoned lands benefit erosion processes
- Subdeserts and permanently desertificated landscapes

As a conclusion, in Developed Countries desertification is not necessarily linked to socio-economic systems decline or recession, furthermore, these countries have sufficient own resources to mitigate its negative effects. Therefore, problems that desertification involve have a lesser social impact, which drifts onto a lack of social awareness, consciousness that would be necessary to carry out an active policy in accordance to the real seriousness of the problem.

## Combating Desertification, Erosion Control and Forestry in Turkey

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Desertification and erosion are important environmental problems of Turkey. Productive agricultural, forest and pasture lands were destroyed by urbanisation, industrialisation, tourism activities, overgrazing etc. in recent years. Combating desertification and deforestation and control of erosion are among the main duties of Ministry of Environment and Forestry. Afforestation, improving pasture and meadows, land rehabilitation and erosion, flood and landslide control activities are conducted efficiently as well as rehabilitation of forest ecosystems. In addition to implementation of the new technologies, it will be useful to increase public awareness.

## Global Attention to Turkey Due to Desertification

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Desertification has recognized as an environmental problem by many international organizations such as UN, NATO and FAO. The UN has been studying about the desertification control since the early seventies because of high world population, unbalanced food production and its negative effects on the economy. In 1992, Rio de Janeiro Environment Conference, the UN pointed the desertification of many countries, such as Turkey. The UN has been studying the desertification control and, actually, it has focused on Africa because it is the most likely place to be desert. The term of desertification often misunderstood. Desertification is a broader concept that not only place is like “desert creep” and “encroachment of the Sahara” but also is a global issue covering climate change, loss of biodiversity and epidemic diseases, wind and water erosion, overgrazing, unsustainable farming practices and urbanization. Desertification in Turkey is generally caused by incorrect landuse, excessive grazing, forest fires and uncontrolled wild type plants picking. Spatial and temporal variations of precipitation aridity index series of Turkey, for the period 1930 and 1993 showed that total annual and winter precipitation have decreased, in 1973, 1977, 1984, 1989 and 1990, severe and widespread dry conditions occurred, due to depletion of winter precipitation, affecting degradation of soil moisture, caused reduction ground water level. For total $CO_2$ emissions, Turkey is ranked 23$^{rd}$ when compared with other countries. Soil erosion is also significant land degradation factor due to topographical conditions. Salt problem has occurred in 4.49% of Turkish agricultural soils. Urbanization and soil sealing also has become a serious problem on the fertile agricultural lands. Due to anthropogenic destruction of forest, steppe flora gradually became dominant in Anatolia. In terms of biodiversity, Turkey has a significant importance in Europe and Middle East. Nine thousands plant species naturally grown in Turkey, one third of them are endemic. Also, endemic species of vertebrates, thrive in the lakes and marshy areas. The studies of modelling simulation of vegetation on the effects of Mediterranean climate during the Roman Classical period by using vegetation history (the pollen method) showed that , in 2000 years BP, Mediterranean countries were more humid than today. Turkey has a special place on the global concern in terms of desertification because of biodiversity, agricultural potential, high population, social and economical structure, topographical factors and strategic regional location. Communication between scientists, decision markers and international non-profit organizations must be improved.

# TOPIC 2:
# CONSEQUENCES OF DEGRADATION ON SOCIAL, ECONOMIC, AND POLITICAL ISSUES: ESPECIALLY ON FOOD SECURITY AND MIGRATIONS

## The role of desertification in deepening the historical conflict between farmers and herders in the arid environments of Northern Africa

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Arid environments show strong limitations to primary productivity due to low water availability. Under this conditions, the population density of the species and the carrying capacity of the system are usually close to each other and recurrent droughts induce reductions in population sizes. Traditional land use systems in these regions are mainly based on cattle raising, being agriculture complementary to animal production when soil and climate conditions allow it. Farming and herding, which in arid regions like Northern Africa are usually practised by different ethnic groups, compete for scarce, key resources such as land and water. As a response to environmental variability, they have established throughout history a sort of relationship based on cooperation during wet periods and on confrontation during dry periods. Given that: i) there is evidence that scarcity, either it is physical (absolute) or economic (relative), is a factor that helps to explain why violent confrontation appears as a way to deal with disagreement between confronting parties, ii) resource scarcity is being enhanced by environmental degradation, iii) the border between these two activities follows a pattern of scattered patches rather than a well defined line marked by a threshold of water availability and, iv) there is a long record of age-old conflicts between farming and herding people, one can expect that desertification will enlarge the likelihood of occurrence of such conflicts. On this poster we will set a theoretical framework that aims to explain the relationship between pastoral and agricultural ways of life and production, and will make a revision of cases in order to asses how land degradation is fostering violent confrontation between farmers and herders in Northern Africa.

## Social-Economic Factors in Development of Desertification Processes

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Desertification reduces capacity of land to restore its potential that is naturally effected by changing climate. A lot remains to be learnt about the interlinkages between desertification and climate, soils, waters, vegetation, animals and especially human activities.

The problem of desertification became more acute especially in countries of South Caucasus. Therefore a new approach of managing ecosystems of draughty areas is needed.

Desertification inflicts huge social costs. Our knowledge of interlinkages between desertification, migration and conflicts is continuously rising. Due to heavy land-utilization, extensive pasturing, weakening and inadequate irrigation, the process of draughty lands degradation in South Caucasian countries is actively proceeding. This heavy land use is a result of various social and economic factors, unawareness, wars and draughts.

Desertification leads to famine. The latter is usual in places which suffer from poverty, civil unrest and wars. Draughts and land degradation sometimes act as catalysts of crisis, which is then exacerbated by inadequate distribution of food and unaffordability of foodstuff.

Desertification leads to migration of population. Increasing volume of data confirms the fact that there is a robust correlation between social contradictions, conflicts such economic factor as desertification.

Land degradation negatively influences the quality and reserves of fresh water.

Draughts and desertification lead to water level decrease in rivers. lakes, and water-bearing horizons. For example, unsustainable irrigation methods may lead to rivers dry up, which supply the lakes. Crisis around water supply increase political tensions in many regions of Southern Caucasus. This is the case especially when border rivers and lakes are involved. Land degradation is one of the main causes of ocean contamination because dirty deposits and washed down soil are brought to the oceans by large rivers.

Desertification causes a huge loss of economic resources. In many regions of Southern Caucasus desertification has lead to serious economics losses. Exhaustion of natural resources caused by desertification leads to decrease in national income. Indirect economic and social costs that are directly incurred by the regions in deserting areas, including the influx of “ecological refugees” and the damage to the national producers of foodstuff, could be even larger.

## La Désertification: Menace ou Opportunité de Stabilité?

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L'Algérie a accumulé une expérience certaine en matière de lutte contre la désertification. Une des principales difficultés consiste cependant dans la mise en cohérence des plans réalisés dans les différents secteurs d'activité afin d'en assurer la convergence. On a toujours parlé de développement intégré, mais on a toujours désintégré les actions. Cette lutte ne peut être menée convenablement en dehors du contexte international du fait de la nécessaire mise en commun des moyens humains, financiers, matériels et scientifiques. La CCD, en tant qu'instrument international et multilatéral, et la concertation de tous les partenaires à la sauvegarde des ressources naturelles, doit donner un élan novateur de partenariat aussi bien au niveau national qu'au niveau régional et inter régional. La nature des changements (sur les plans socio-économiques, technologiques, démographiques, et politiques) ont fait émerger la question de la dégradation des ressources naturelles comme une question majeure. On analysera l'intégration de cette question dans les conduites sociales, dans les politiques environnementales et les politiques de développement agricoles et/ou rurales. Nous présenterons l'analyse des actions publiques nationales ou, parfois internationales, visant à promouvoir le développement local et le développement durable telles qu'elles ont été discutées dans les différents ateliers de concertation. Enfin seront abordées également les dimensions nationale et régionales du problème de la dégradation. Il s'agit de faire face, dans une perspective de développement durable, à des problèmes de gestion des ressources naturelles dans un contexte, physique mais aussi socio-économique, de dégradation de ces ressources, lié à la sécheresse et à l'aridité. Ces phénomènes posent toujours le problème de l'identification des causes socio-économiques des processus induits, que ces causes se situent à un niveau macro ou à un niveau plus localisé. En conséquence, il apparaît nécessaire d'approcher la désertification par une entrée en termes de dégradation/protection/gestion des ressources naturelles. Mais il s'agit aussi d'interroger les modalités d'utilisation de ces ressources naturelles par les populations, car elles sont liées à des fonctions économiques (productions agricoles et industrielles) mais aussi environnementales, institutionnelles et culturelles. Il s'agit surtout d'aborder les aspects socio-économiques institutionnels et politiques de la dégradation des ressources naturelles. L'analyse des stratégies et des actions mises en œuvre à travers les expériences réalisées, (tels que le PNR, le PER, le PNDA, le PNDAR et autres) peuvent constituer de nouveaux lieux d'apprentissage politique et social d'une gestion durable des ressources naturelles, de nouveaux mécanismes de gouvernance, de nouveaux biens économiques et de nouvelles institutions qu'il s'agira d'analyser dans leur émergence. S'il apparaît nécessaire d'inscrire le programme de lutte contre la désertification parmi les priorités dans les programmes de développement économique et social, il est tout aussi nécessaire d'instaurer un dialogue permanent, participatif et consultatif, entre les pouvoirs publics et tous les acteurs intéressés.

## The Implementation of Policies and their Effect on Land Use Changes and Population Dynamics: A Case Study in Southern Italy

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The present work illustrates some outcomes from the Medaction project, which aim has been to study the effects of past international, national and regional policies on land degradation and desertification processes.
The case study area- the Agri basin- has been chosen in Basilicata Region (Southern Italy), being affected by serious land degradation processes. This basin is characterised by an heterogeneous physical, social and economic situation. This has been reflected in different choices about land use change and population dynamics in the past 20 years.
The study has been conducted in two following steps. Firstly, 34 in-depth interviews have been held among local, regional and national stakeholders. Secondly, a survey has been conducted on a sample of 106 farms in the case study area, recollecting information on structural, social and economic issues, as well as on farmers' perceptions on the effect of policies and on desertification issues.
The information obtained by in-depth interviews depicts the institutional network at different spatial levels, from the national to the local level, and the power relations among different actors. Hence, it has been possible to analyse the effects of the implementation of sectorial and inter-sectorial policies, and how they effected on the local communities.
The survey offers a broad insight on farmland and farm society evolution got from the grass root point of view. Despite the limits of a small sample, key information about power relation within local communities and among local communities and institutions have been depicted.
Results from these sources, together with a broad analysis of secondary data, give an interpretation of how policies have affected the decision making process on land and water use, as well as they have deeply influenced land degradation and social dynamics.

## The Problem of Deforestation in Morocco: Causes and Consequences

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The Moroccan forest is composed of about nine million hectares of natural woodlands and 0.5 million hectares of plantations which cover almost 13 percent of the whole territory. Most of this forest in not economically important as far as timber production is concerned, but it provides a range of benefits such as fuelwood, fodder, medicinal plants, and contributes to the maintenance of the ecological equilibrium by protecting soils and biodiversity habitats, improving the water quality and quantity, trapping carbon dioxides, and so forth.

These forests are composed of heterogeneous species with a low cover density. They are diverse but very vulnerable and not very resilient due to harsh weather conditions and to soil poverty. Their state is being rapidly evolving due to pressures induced by ecological, social and economical constraints, which lead to diverse forms of degradation. The country is experiencing an average loss of 33 million hectares of its forest. This deforestation is mainly caused by human related activities such as fuelwood gathering and grazing.

Land degradation is closely linked to this deforestation, which is ultimately related to the pressure of people, with no resources to fall back on, who are forced to put immediate needs before the long-term conservation objectives. The declining vegetation cover simplifies the landscape, reduces land quality and has a major impact on agricultural productivity and on biodiversity erosion. It also affects water resources by reducing the water quantity and quality and leads to flooding in some areas. Traditional systems of land use are either threatened break down in some parts of the country or are no longer appropriate in other parts due to population pressure, declining soils fertility or shortage of water availability.

Much progress has been done in the recent years on promoting forest plantations and on attempting to manage sustainably some forest stands. We can cite the Master plan of plantations, the encouragement of partnership with private sectors and NGOs, the efforts made on the establishment and sustainable management of protected areas, etc.. However, more efforts and financial means are needed to preserve lands that still retain some permanent vegetative cover. Important considerations for effective techniques of conservation need to be developed and the idea that conservation and resource use are two sides of the same coin is essential to promote. The absence of interdisciplinary and integrated approaches between the natural and social sciences, and the lack of an effective participation and involvement of all stakeholders are among the obstacles, which face up the conservation of forests and the combat of desertification.

## Land Use Change Detection as a Basis for Analysing Desertification Processes; a Case Study in Tabernas (Almeria, Spain)

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This contribution shows an integrated approach to detect and quantify land-use and land-cover changes as a basis for studying and predicting changes in environmental processes leading to desertification. The approach has been applied in Tabernas (Almería, Southeast Spain), a representative area of the Mediterranean region where a combination of extreme environmental conditions and modification of the land use pattern occurred in the last decades have led to increase the risk of desertification.
The approach is based on multi temporal records of remotely sensed data and field survey. Sets of aerial photograph taken in the fifties (1956), the eighties (1981) and the nineties (1995) were used to map land use and cover in the three different periods of the last fifty years. The results indicate that most of the changes in land use have taken place in the study area after the year 1981. The main land cover type that was subjected to change is the seasonal cultivation. About 63% of the affected land (2.500 ha) has changed to irrigated farms for olive and almond cultivation, 28% has been abandoned, and about 5% has been subjected to activities (infrastructures, industries, etc.) that have left the area without vegetation cover. The abandoned area has evolved to an area with a weed type non-permanent bush cover, which is totally different from the natural cover in the area. The land abandonment and the change from seasonal crop cover to irrigated tree cover seems to exert pressure on the environment, that can lead to an increase of desertification processes such as soil erosion, salinisation and pollution. Most of the recent irrigated farms are on slopes ranging from 2 to 8%. Important erosion processes can occur both on these slopes and on abandoned areas depending on other influencing factors (e.g. soil erodibility).

# TOPIC 3:
# SOIL AND VEGETATION MONITORING TECHNIQUES AND PROGRAMS

## Soil Dispersion, The Common Factor in Soil Degradation: How Well Can We Measure and Manage Them ?

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***The fundamental cause of soil degradation:***

Our current knowledge and experience about soil degradation, its prevention and management is very fragmented across the different continents and there is an absence of a fundamental framework that can readily bring them together. This is largely due to the different perceptions of the cause of degradation and how to measure them.

Current methodologies for the measurement of soil structural degradation has been highly empirical, hence results have been soil or site specific and of a qualitative nature. Studies on one site does not necessarily apply to other sites. If they do apply, they are only applicable in a qualitative sense. As soil degradation does not recognize international boundaries, we need to be able to quantify degradation in a universal manner that applies to all soil types and can be used quantitatively for all definable conditions. Results from one study can then be transferred to other site, countries and conditions. As soil degradation in a global sense is very severe and threatens the productivity of cropped lands and the security of food supplies, particularly in the semi-arid and arid regions of the world, there is an urgent need to develop suitable methodologies that is universally applicable.

***Progress in characterizing soil dispersion:***

At the University of Queensland, for some years we have been searching for an energy based measure of soil degradation that can be applied universally. We have shown conclusively that slaking and particularly dispersion is the root cause of many soil physical problems, such as surface crusting, hardsetting, compaction, surface waterlogging, decreased soil workability, trafficability and increased compactibility and erodibility. Small dispersed particles simply block the larger pore spaces, leading to decreased infiltration and subsoil water recharge, a major factor determining yield in semi-arid and arid agriculture. Dispersed particles are also the major cause of off-site impacts of soil degradation and carries a disproportionately large part of the soil chemical fertility.. This unifying concept is cited in the latest soil monograph/textbook edited by Sumner (2000) and is published in the latest reference work the Encyclopaedia of Soil Science (2002).

***Can we measure dispersion and the energies of dispersion ?***

The fundamental starting point we adopt is the simple observation that “degradation is the disintegration of the bonding in soil aggregates (the structural unit) by the application of a mechanical energy from man induced cultivation or natural forces such as rainfall”. Despite its simplicity, there is a total absence of knowledge on the energies of aggregate bonding and the energies that breaks soil aggregates. We have developed a novel ultrasonic-calorimetric technique that can be used to measure the energy of dispersion as well as the amount of dispersed materials and the relationship between the two is called the Soil Dispersion Characteristic (SDC). The SDC will form the basis for the development of an energy based soil structural stability measurement that hopefully can be universally applicable.

***Can we manage dispersion ?***

Yes, we know quite a bit about the management and prevention of soil dispersion and how to minimize structural degradation. Various options will be discussed.

***What is the prospect for international collaboration ?***

Finally, can we mobilize the international community of scientists and managers to jointly develop a common methodology and to develop options for managing soil dispersion and degradation suitable for different sets of conditions ? Can we slow down the rate of soil degradation and eventually prevent the loss of our most precious non-renewable resource ?

## Fighting Land Degradation in the Mediterranean through Forest Landscape Restoration

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Ill conceived land use policies and unregulated management practices in the Mediterranean have resulted in over-exploitation of natural resources. This has led to acute environmental damage, biodiversity loss, and desertification, thus endangering the livelihoods of millions of people.

The provisions in the United Nations Convention to Combat Desertification focus on rehabilitation of land, conservation, and sustainable management of land and water resources. In the context of implementation of this Convention, a number of countries in the Mediterranean have initiated actions or adopted policies related to forests. The role of forests and forest ecosystems in combating desertification is clearly recognised in documentation prepared by the CCD Secretariat and by parties to the Convention. As stated in a Note by the CCD Secretariat on collaboration and synergies among the Rio Conventions, forests are instrumental in forestalling desertification, both directly through their effects on soil and water, and indirectly through their role in mitigating climate change and supporting biodiversity. The Secretariat's Note further states that dryland deforestation contributes to desertification, and reforestation of desertified land is a means to combat desertification.

The IUCN Centre for Mediterranean Cooperation, WWF and their partners are promoting Forest Landscape Restoration as a process that aims at regaining ecological integrity and enhancing human well-being in deforested or degraded forest landscapes. This process focuses on restoring the functions that forests provide - such as food, habitat for species, soil stabilisation, medicinal plants - at the broader landscape level as opposed to solely promoting increased tree cover in a particular location. Forest Landscape Restoration can also act as an entry point to strengthen synergy among the UN Conventions on Biological Diversity, Climate Change and Desertification, and several experiences from the region have expanded it as a key mechanism to develop concrete programmes to combat desertification.

## The size and effect of rock fragments on post fire erosion characteristics

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The experiment was conducted in 30 experimental plots which were installed on a hillside. The study was consisted in the effects of different size, amount and position of rock fragments on soil properties and erosion after a fire event.
The experimental plots were exposed to 378 mm total annual rainfall comprising selected combinations of rock fragments size (cobbles and gravels), position (incorporated partially embedded) and cover percentage (10.4, 17.8 and 22.6%) and bare soil. During the experimental period, different parameters were measured such as: the amount and total duration of the precipitation in the area, the runoff from the experimental plots and the sediment yield. In addition every month there were measurements concerning the vegetation cover of the experimental plots.
The largest amounts of runoff and sediment yield over five rainfall events were from bare soils containing abundant rock fragments either partially embedded on the surface or incorporated in the upper part of the soil. Stonelles soils gave smaller amount; generally, large rock fragments, cobbles resulted in higher runoff and sediment yield that that of smaller rock fragments such as coarse gravel.
Sediment yield loss was greater from soils with cobbles than from soils containing coarse gravel.

## Optimal Bioengineering and Forests for Erosion Control in Mountainous Catchments with Mediterranean Climate

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The cover provided by vegetation makes it possible to fight erosion efficiently. Furthermore, vegetation barriers can also play a major role by trapping sediment eroded upslope. Researches carried out in the Mediterranean part of the French Alps showed the importance of the spatial distribution of vegetation in reducing sediment yield at gully exit: only 20 to 30 % of low vegetation, located downslope of a gully, can be enough to stop all sediment eroded above. This shows that it is not necessary to establish total vegetation cover in a gully to stop the sediment yield at its exit. Thus, it is possible to propose optimal strategies for erosion control in mountainous catchments with Mediterranean climate, with the use of bioengineering and forests. Intervention priorities are proposed at different scales (region, catchment, and gully) for different restoration contexts. Intervention rules, with bioengineering or forest harvesting techniques, are also proposed. Concerning restoration of eroded ecosystems, at the region scale, catchments to restore in a priority way can be determined according to socio-economic stakes and erodability. In these catchments, topography and presence of natural vegetation can help for the choice of the gullies to restore first. In degraded gullies having priority, it is possible to determine the minimal surface area to restore with vegetation and bioengineering structures. Strategy elements for the choice of the biological structures to use are then proposed. Concerning monitoring of restored ecosystems, a method to determine Priority forest intervention zones at the region scale is proposed; it allows to determine intervention priorities for the different forested catchments. At the catchment scale, it is then possible to determine the gullies where interventions must be carried out in a priority way. To do this, a gully typology is proposed. For each gully type, as it is not necessary to perennialise the total vegetation cover to guarantee the absence of sediment yield at the exit of gullies, rates of minimal interventions are proposed: what is important is to maintain vegetation cover downslope of the gully. In restored gullies having priority, strategies for bioengineering structures maintenance and sylvicultural management are proposed, in particular concerning harvesting techniques.

## The Present State of Desertification in The Valencian Community According to Environmental Factors

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The estimation of present state of desertificationin the Mediterranean countries is necessary to propose mutual planning policy on these subjects.
The complexity of obtaining the necessary information in a complete and straightforward way leads to the decision and selection of the most relevant factors that will express, in a simple way, the present situation of each territory.
The aim of DIS-MED project is to create a map of sensitivity to desertification and rests on soil, climate, vegetation and planning systems as the four main factors involved in desertification.
In the Valencian community, following these principles, and on the basis of existing information generated by the University of Valencia, CSIC and CIDE, the factors determining the sensitivity of an area to degradation that have been selected and studied are: soil type, slope, lithology, climate and land-use. In this paper the role of the soil factor in desertification is emphasised. The soil is evaluated according to FAO, 1988 incorporating its state of evolution, the processes involved and its condition as climax soil in the Mediterranean environment.
The evaluation contemplates each one of these factors grouped in three levels of possible protection to desertificacion: Favourable, unfavourable and very unfavourable.
The final treatment unit is product of the weighted combination between these factors and is characterised by a higher or lower sensitivity to desertification according to the limitation that they show, and are classified in four states**:** low , moderate, high, severe.
The result of the application of this methodology in the Valencian community is a map where 30% of the total area presents a slight level of state, 28% presents a moderate state, 9% a grave state and 15% a very grave state. The rest of the area (18%) is miscellaneous.

## Soil Water Erosion and Agriculture In Spain. A State-off-the-art throughout the Scientific Literature

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It is widely assumed that cultural and natural conditions explain the high soil erosion rates found in the Mediterranean countries. A semiarid climate with intense thunderstorms with low vegetation cover and erodible soils are some of the reasons of the highest erosion rates measured in the Spain. But, the human activities are also key factors that explain the accelerated soil degradation and erosion. Forest fire, grazing, urbanization, land abandonment, felling of trees and shrubs are some of them. Agriculture is probably the most aggressive human activity under semiarid climatic conditions because removes the natural vegetation and litter, and plough frequently the soil.
After 20 years of soil erosion studies in Spain, data has not been reviewed or discussed within the scientific community. An accurate review of the scientific literature on soil erosion in Spain shows that available data is scarce. Moreover, the variability in plot size and the period of time under study make comparisons between the results of different studies very difficult. However, it should be highlighted that agriculture is key factor that explain the present high erosion rates in Spain due to the lack of soil conservation practices. The highest soil losses were found under rain fed cultivation, such us olive, vineyards, cereal or almond trees. Conservation agriculture should be encouraged in order to avoid soil degradation and erosion. Agriculture has produced some of the greatest soil losses through the impacts of tillage, reductions in vegetation cover and the encouragement of widespread surface run-off.

## Monitoring tools to assess vegetation successional regression and predict catastrophic shifts and desertification in Mediterranean rangeland ecosystems

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The relation between grazing intensity and ecosystem performance may depend on the phase state of the ecosystem. Previous studies have revealed that, in traditional grazing ecosystems, grazing may affect the system in two opposite directions: a) reducing diversity ecosystem performance, especially in poor soils; b) or increasing diversity and productivity of the ecosystem, particularly in natural ecosystems or under low grazing pressure in rich ecosystems. We are interested to detect long-term structural changes or drift in an ecosystem before is too late to prevent irreversible degradation. We studied the spatial patterns and complexity of five Mediterranean communities: Tihmadit region (Middle Atlas, Morocco), Camiyayla (Namrum) region (Taurus mountain, Turkey), Sykia region, south of the Sithonia peninsula of Greece; Cabo de Gata Nijar Natural park, and Sierra de las Nieves in South of Spain. Disturbance is most intense near the shelter and/or water points, producing a gradient of soil surface disruption, compaction, and change in composition and cover of perennial vegetation. We examined the effect of livestock grazing on the diversity, spatial complexity and, thus, indirectly, the community stability in the Mediterranean ecosystem. We used Information indices to measure change in information flux with grazing, and the information fractal dimension to measure its spatial components. The results show that woodland and dense matorral (scrubland) are more resistant to species loss than middle dense and scattered matorral, or grassland. Information fractal dimension declined as we moved from a dense matorral to a discontinuous matorral, increasing as we moved to a more scattered matorral and to a grassland. The results are in accordance with our expectations and the theory of self-organized instability, that hypothesize that ecological complexity results from the interaction between the trend to increase diversity as ecosystem develops and the negative feedback aroused from interactions among individuals (Solé et al. 2002). Resulting two opposite processes (interaction declining with ecosystem development, and immigration increasing with degradation) in a common pattern, i.e.., small patches homogeneously distributed into the landscape. In all studied cases, the characteristic species of the natural vegetation declined in frequency and organization with grazing disturbance. Heliophyllous species and others with postrate or rosette twigs increased with grazing pressure, particularly in dense matorral. In the more degraded ecosystem only species with well adapted traits, e.g., buried buds, or unpalatable qualities, showed a clear increase with grazing. Indeed, the homogeneity of species distribution within the plant community declined monotonically with grazing impact. Conversely, the spatial organization of the characteristic plants of each community increased in the better preserved areas, being also related to the sensitivity of the species to grazing impact. The degree of autocorrelation of plant spatial distribution at the species level, and the information fractal dimension at the community level allow us to quantify the degree of degradation of natural communities and to determine the sensitivity of key species to disturbance.

# Climate Change, Land Degradation and Desertification in the Mediterranean Environment

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Until the early seventies land degradation and desertification were not considered a major issue in most Mediterranean regions. Traditional agricultural systems were believed to be able to keep those processes in check. Thus low priority was assigned to research programmes and projects on soil erosion and conservation, preference being given to the impact of farm machinery on soil structure and compaction along with the role of organic matter in the soil.

In the eighties and early nineties the agricultural practices introduced in sloping land under cultivation in the Mediterranean in previous decades were identified as a major contributor to soil degradation. The unprecedented efforts to increase crop yields and maximize profit, made possible by the technological revolution in agriculture, had triggered in the agricultural ecosystem the onset of soil degradation due to hydrological phenomena that proved detrimental both to soil fertility and to the landscape causing devastating and permanent damage. In addition, it was recognized that research activities were too fragmentary to be able to cope with the demands of implementing sound soil conservation measures.

The Mediterranean climate is characterised by hot dry summers and mild wet winters. The region frequently suffers from years of scant rainfall and many areas are afflicted by severe drought. The UK Hadley Centre's global climate model has been run on a monthly basis for the Mediterranean countries to predict the percent variation in rainfall and temperature with respect to mean monthly values. Scenarios developed using the model show that for the wet season (October-March), by the year 2050 rainfall could increase in central and eastern Spain, northern France, northern Italy and the Alps by up to 15%, against a decrease of about 10% to 15% in the southern Mediterranean. For the same period, the temperature in the northern Mediterranean is predicted to increase by 1.25° to 2.25°C, compared to an increase of between 1.5° and 2.5°C in the southern Mediterranean. The projections also show that for the dry season (April to September), by the year 2050 rainfall is likely to decrease over much of the Basin. Decreased precipitation is predicted to be accompanied by a rise in temperature of between 1.5 and 2.75°C in the northern regions and 1.75° and 3.0°C in the southern Mediterranean. Reduced precipitation during the summer has a major impact on irrigation and tourism, which both increase the pressure on water supplies during the dry period.

To combat these problems, the European Community (EC), in collaboration with other international organizations, has funded various programmes and projects for mitigating drought and assessing and preventing land degradation and desertification.

In this context, the paper describes the main features and characteristics of some of these programmes and projects and proposes new approaches to environmental policies, in order to:

- assess, forecast and mitigate adverse impacts of drought;
- better understand soil erosion, land degradation and desertification processes;
- identify preventive, protective and remedial measures;
- address quantity and quality of natural resources in an integrated context;
- support innovation and participatory strategies.

The importance and role of institutional strengthening, sound financial and managerial frameworks, availability of human resources involved, research thrust, technology transfer and networking improvement are also highlighted.

# TOPIC 4:
# WATER RESOURCES AND MANAGEMENT

## Forest Hydrologic techniques as a tool to increase security against environmental risks leading to desertification

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The forest hydrologic restoration is a widely used method to reduce erosion and combat desertification in Mediterranean areas. The main interventions considered in this method are: i) afforestation of degraded lands, and ii) the use of stabilization structures , mainly check dams, for gully erosion control. However, the actual effects of these works and their effectiveness are not well known.
The objective of this study was to evaluate how effective check dams are to address hazard risks to the environment (erosion and flooding) which could cause economic instability and conflicts in relation to scarcity of resources in developing countries.
The results from the Carcavo catchment in the South East Spain show:

a) For a bigger efficiency the check dams must be settled in ephemeral channels with fluvial activity in high sediments production areas. Preliminary studies on erosion-deposition are necessary to develop a GIS-based model able to predict the most suitable places to install to install the check dams.
b) Changes in the sediment transport and deposition are caused by the check dams. These changes lead to higher deposition upstream and erosion increase downstream from the check dams.
c) Once the check dams are full-filled, its sediment retention capacity is loosed. However a permanent effect of decrease in the slope gradient appears, which leads to a reduction in runoff velocity and consequently to a better control of hazard risks leading to desertification.
d) Deposition of fine-size particles and saline material occur in most check dams. These sediment are sensitive to piping erosion. In these cases, water flows under the check dams and this lead to its demolition. Check dams need to be supervised and restored to keep the performance.

In conclusion, the check dams show positive effects in relation to sediment control and reduction of runoff erosivity, increasing security to prevent flooding risks, reservoir filling and desertification. However, some negative effects such as the increase of vertical and side erosion downstream can occur. For optimising the performance it is necessary an appropriate selection of check dams location and a monitoring programme by an indicators systems. This systems will enable to assess the effectivity of the check dams to improve the benefits of current works as well as the future actions.

## Management of Forest Soils Considering Water Erosion as a Control Factor

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In Mediterranean regions, water erosion is strongly linked to desertification and relates mainly to constraints of land use. Soil and water play very important roles as production factors in agriculture and forest crops, so they are of almost importance in the management of forest soils for sustainable productivity.
The density of plants, the amount of water available and the soil properties are aspects to take in account in the management of forestlands. The lower stage canopies of bushes and herbs established in forest lands compete for water with the trees, but are important in the maintenance of ecosystems and absorbing the energy of rainfall and throughfall, thus reducing soil erosion.
In the assessment of the available water and the rainfall erosion it is necessary to know the hydrologic behaviour of tree canopies and mainly the role of the leaves. The major aim of this study is to present and analyse the role of the leaves in what concerns canopy interception, retention and throughfall and to present values of leaves' retention and throughfall erosivities, obtained experimentally.
Typical conditions, in Southern Portugal, are presented for mixed stands of cork and evergreen oaks, with cereals or pasture covers, and eucalyptus.

## Demonstration-Site-Based Research, Education, and Exchange of Information on Sustainable Land Use in Arid and Semiarid Areas

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Drought and soil salinization, mainly due to inappropriate irrigation practice, are an escalating problem worldwide. The necessary large-scale use of recycled and saline waters to replace fresh water for agriculture further accelerates this problem. However, most crop species are sensitive to salinity and show impaired growth and development under drought and salt stress. Efficient osmotic adjustment and ion homeostasis are two major objectives sought by plant breeders to improve salt and drought resistance of crops. Halophytes are good candidates as genetic sources for traits of salt resistance. On the other hand, plant species differ greatly both in their metabolic capacities and in strategies to respond to salt and drought stress. Moreover, it is generally accepted that plants have to cope with additional stress factors in the field. Therefore, laboratory-designed plants that showed very promising behaviour in greenhouse experiments, in most cases failed to give the expected yields in field trials. Such problems cannot be solved by a single research team, but call for intense cooperation between groups of specialists with access to modern laboratory equipment as well as test fields in arid areas. These test sites are open to the public and are used as demonstration sites showing our results in order to convince farmers and local representatives. Another advantage of multidisciplinary cooperation is that it provides the opportunity for team members to undergo training in the framework of exchange programs. This is done in our project on the basis of bilateral agreements. For example, the work of Ph.D. students is supervised by advisors from partner universities in "tandem-teaching" arrangements. Moreover, during their visits, researchers from the partner laboratory give seminars and their insight provides students with an in-depth understanding of the problems in our partner countries.

## Oasification: A Forest Solution to Many Problems of Desertification

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Desertification is a very common process on deforested slopes under arid, semi-arid or dry sub-humid climates. Against this problem, we opt for a choice that involves promoting the opposite process, called oasification. It consists of building small earth structures to collect and infiltrate the whole precipitation and runoff by modifying a slope's physiography in a convenient and non-aggressive manner. Thus, better moisture conditions can be achieved in the soil and the establishment and growth of woody vegetation can be readily attained, redressing the dangerous process of desertification.
Since ancient times, many water harvesting strategies have been used successfully in most regions of the world with scarce precipitations (microcatchments, ridging, terracing, etc) by stopping, collecting and infiltrating surface runoff. Nowadays, we can design these structures with hydrologic criteria based on sound knowledge of water economy, water requirements, building costs and landscape impacts. These criteria should help land managers and technicians to choose planting densities and micropond sizes with a view to obtaining the best survival rates of the seedlings with minimal alterations to the original physiography of the slope.

## Wastewater Effluent Survey

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The increasing usage of treated wastewater effluent in recent years is an additional stage in the development of the water policy. The increase in the amount of treated effluent usage for irrigation is due to the reallocation of potable water from the agricultural sector to the urban population, and an increase in the amount of treated wastewater effluent irrigation to orchards. Fruits are more sensitive to the effluent water quality (total dissolved salts, chloride, sodium, and boron) than field-crops, which in the past were the leading consumers of treated wastewater effluent. The main restriction in using treated wastewater effluent for irrigation is the chemical water quality.

The current water quality of some wastewater may cause damage to agriculture prior to the contamination of water sources. In certain cases, the damage may be intense, immediate and easily identifiable. In other cases, the damage may develop over time in the plants and soil. In this latter case, the damage may be to the soil's capability to support plant life, or in a decrease in plant yield in due time. In this case, it is harder for the grower and for researchers and advisers to identify the reasons of the gradual changes from year to year. In the framework of the National Wastewater Survey, a long-term observation study was conducted to identify and quantify any hazards in irrigating crops with wastewater, in order to:

1. Help to set policy to prevent water pollution by home, industrial and agricultural use;
2. Help to set policy to treat wastewater for agricultural use;
3. Help to match the agro-techniques to the water quality, to introduce the necessary changes in irrigation and fertilization, to find suitable rootstocks and varieties, and soil suitability.

The survey methods include:

1. Soil sampling and analysis twice a year, in the end of the raining season in the spring and in the end of the irrigation season, in the autumn.
2. Leaf Analysis once an year, in the autumn and analyzed to nutrients, Cl, Na and B content.
3. Water Analysis: The irrigation water is sampled in the plot, four times in the irrigation season.
4. Data collection

# TOPIC 5:
# FORECASTING TECHNIQUES AND ADVANCES TECHNOLOGIES

## Using a GIS to Sustainable Use and Management of a Irrigated Area Border between Spain and Portugal

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The incorrect irrigated land management, using excessive amounts of production factors, namely pesticides and fertilizers, can be responsible for a fast and irreversible degradation of the soils and their productive capacity. In order to contribute to a sustainable management of an irrigation area, located in the border between Portugal and Spain, 1428 georeferenced topsoil samples were taken. Selected soil properties as pH, organic matter, electric conductivity, sodium exchangeable and available phosphorus and potassium were analysed. Using Geographic Information System (GIS) software, which allows the storage, management, analysis and display of georeferenced information, parametric maps for previously referred properties were elaborated; the zones of higher fertility and, therefore, the more capable areas for the more productive and exigent cultures were also established. Simultaneously, predictive maps for organic amendment and mineral fertilization were elaborated to assure a sustainable and integrated land management for the study area.

## Use of Anchor Stations in Land Surface Process Studies. Validation Activities at the *VALENCIA ANCHOR STATION* Site

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Desertification processes resulting from a combination of factors that include climatic variations and human activities should also be approached by using long term observations supported by models and retrospective data evaluation. Anchor Stations and observations from space therefore play a major role in land-surface research.

Anchor Stations are instrumented sites to measure in representative areas quantities which are needed to run, calibrate, or validate models or algorithms such as, for example, those that are needed to evaluate quantitatively satellite data and to convert them into geophysical parameters. The stations must be instrumented with equipment for long time measurements of basic quantities (meteorological and hydrological background data) as well as other quantities that are not readily assessed at operational meteorological and hydrological stations (surface albedo, the four components of net radiation, soil heat flux, sensible and latent heat flux, carbon fluxes, water fluxes in the soil, Bowen ratio, spectral atmospheric optical depth, atmospheric water vapour, aerosol parameters, ground water level, soil moisture, vegetation parameters, etc). Besides, Anchor Stations must offer the infrastructure to undertake more refined measurements for shorter intensive observation periods in the surrounding of the station.

The *VALENCIA ANCHOR STATION* has recently been set up in the *Utiel-Requena Plateau* (Valencia, Spain) with the specific objective of developing a suitable methodology to validate low spatial resolution remote sensing quantities. The scientific inauguration of the site has been the successful development of the first GERB ground validation campaign, where CERES instruments on Aqua and Terra provided specific additional radiance measurements operating in the PAPS (*Programmable Azimuth Plane Scanning*) mode, simultaneously with GERB observations from MSG (see http://asd-www.larc.nasa.gov/PAPS/CERES_Spain.html and http://asd-www.larc.nasa.gov/PAPS/cgi-bin/spain/lopez.pl). Ground measurements were taken by LIDAR, sunphotometer, GPS precipitable water content, radiosounding ascents, together with the operational meteorological station measurements at 2m and 15m. The area of the Anchor Station is of about the GERB pixel size (50 by 50 $km^2$) and is reasonably homogeneous, being its spatial homogeneity currently been assessed by using geostatistical techniques (semivariogram) together with two-dimensional wavelet transforms from high resolution satellite images. The *VALENCIA ANCHOR STATION* area is also being taken as reference for comparison of land surface processes in other areas of the *Valencia Autonomous Region*. For example, the analysis of 10-day composite SPOT/VEGETATION data between April 1998 and August 2001, with a spatial resolution of 1km shows that, although the *VALENCIA ANCHOR STATION* area is not apparently undergoing significant desertification processes, it may be a vulnerable area because, in spite of having an average vegetation index of about 0.25, with a percent variability range below 0.10, its minimum value of about 0.15 is perfectly comparable with the corresponding minima in other more degraded areas of the *Valencia Autonomous Region*, as for example, some inner parts of the Province of Alacant. Our aim is to select another Anchor Station area in an objectively more degraded area where a comparison could be made with the *VALENCIA ANCHOR STATION* as regards the evolution of meteorological parameters, surface energy fluxes and fluxes of trace constituents (like $CO_2$), and of suitable remote sensing indicators that could be defined and monitored in both Anchor Station areas. This paper shows the capabilities of the *VALENCIA ANCHOR STATION* as a reference station for validation of remote sensing data and products, the ground support provided in the first GERB ground validation campaign with a large deployment of atmospheric measurements to facilitate cross validation of GERB and CERES, and the workplan we are designing to complement different desertification approaches by studying the interactions between desertification and climate. This is being defined by objectively analysing and monitoring suitable experimental field data from two different climate conditions areas at a different desertification development stage, where two Anchor Stations will be available.

## A Strategy Using Soil Surface Information to Assess Risk to Desertification and Social Security

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Desertification is defined as land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities (UNCCD, Article 1). Desertification impacts not only the landscape – the vegetation, soils, and hydrology – but also associated human populations and their livelihood. Dryland soils are particularly at risk – their low levels of biological activity, organic matter, and aggregate stability can easily result in their degradation as evidenced by increased erosion, reduction in moisture retention, and increase in surface runoff. A concomitant reduction in plant cover (as well as species composition) exacerbates these processes and can lead to what Schlesinger et al. have described as a relocation of soil resources, and a decline in sustainability that is difficult or impossible to reverse.

This paper describes the process of soil degradation and associates the process with changes in the societal indicators of desertification including agricultural and rangeland productivity, loss of income, population outmigration, a loss of dignity, and poverty. We show that an understanding of soil indicators can assist existing indicators to strengthen early warning systems for both increased desertification and an attendant increase in the risk to social and political instability.

## Climatic Feedbacks and Desertification: The Mediterranean Model

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Our research indicates that the precipitation regime in the Mediterranean Region is very sensitive to land-use changes. Perturbations accumulated over historical time have induced changes from a monsoon-type regime, with frequent summer storms over the mountains inland, to a regime dominated by closed vertical recirculations where feedbacks favour the loss of storms towards increasing torrential rains over the coast in autumn. This evolution could explain present desert-like conditions along the coasts of Algiers, Tunisia and southeastern Spain, all of which were covered with vegetation in historical times. Moreover, perturbations to the hydrological cycle in any part of the basin could propagate to the whole basin and adjacent regions through the same feedback mechanisms which increase Mediterranean cyclogenesis and torrential rains anywhere in the basin. These findings, and the questions raised, are relevant for the new EU water policies, and for the future of regions still dominated by monsoon-type weather systems.

## The ANTENNA project: a satellite data network in the Mediterranean Basin

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The TeleGis laboratory of the University of Cagliari, through a National Operating Program, is activating a system of direct reception of data from the MODIS sensors using 36 spectral bands from the satellites Terra and Aqua. The data, collected from multiple daily orbits, relate to an area that extends from northern Europe to the southern Sahara, which includes the entire Mediterranean Basin. One of the goal of this project is the free distribution of these satellite data through our web-site. These are extremely interesting data for the daily monitoring of a series of environmental topics including observations on dust transport, sea temperature, vegetation stress, large geological structures, etc. Plans for project ANTENNA include the possibility of developing a network of laboratories and institutional bodies interested in receiving these data for free. Each one may become a centre of interest for the development of common applications or may simply collect data only when needed.

MODIS is viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands between 0.405 and 14.385 µm, and at three spatial resolutions – 250m (Bands 1-2), 500m (Bands 3-7), and 1,000m (Bands 8-36). Swath width is 2300 km for all channels. The MODIS Science Team, NASA, has already developed 44 products (MOD01-MOD44), but most of them have not yet been completely calibrated or validated by ground-truth data in various ecological systems. The instrument is able to estimate surface temperature with a spatial resolution of 1 km. Furthermore, it is equipped with channels to measure the ocean colour from 415 to 653 nm (1km resolution), determine chlorophyll fluorescence at the water surface and measure the chlorophyll-A amount. Besides that, it is capable of obtaining information on vegetation and land properties, land cover type, vegetation indices and snow cover and reflectance (500 m resolution). MODIS can obtain cloud cover with 500 m resolution at day and 1000 m at night, furthermore it determines cloud and aerosol properties, biomass burning, global distribution of atmospheric stability and total rain water.

Our interest is focused on monitoring Mediterranean area and to compare along a transept north-south from Sardinia to Tunisia the different environmental features in a multi-temporal and multi-scale approach with particular interest on degradation and desertification phenomena. The MODIS data will be a useful way to observe with a good ground and radiometric resolution the global changes during the seasons and to propose a environmental model for landscape evolution.

# POSTER PRESENTATIONS

# TOPIC 2:
# CONSEQUENCES OF DEGRADATION ON SOCIAL, ECONOMIC, AND POLITICAL ISSUES: ESPECIALLY ON FOOD SECURITY AND MIGRATIONS

## Past and present land use changes in the Priorat vineyard region (NE Spain): Historical aspects and new trends

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The present work reveals the accelerated and uncontrolled extension of vineyards in the Priorat region (NE Spain), where the productive area has increased by 100% in the last decade. The study area has a surface of 180 $km^2$. Vineyards are traditionally planted in hillslopes (slope degree >15%). Soils are classified as Xerorthents and are locally called "llicorell". The parent material is Palaeozoic schists, which confers high stoniness to soils (90% in most of the cases). Other typical soil characteristics are their loam sandy to sandy texture, high infiltration capacity and low fertility that, together with the low annual rainfall in the area (450 – 600 mm), limit vineyard production (6000 kg $ha^{-1}$ as maximum). These characteristics, precisely, determine the quality of the Priorat wines. Vineyard is present in the region from the beginning of the XII century, and had its maximum extension in the XIX century, when the population reached 28000 inhabitants. At the beginning of the XX century, overproduction and the philloxera induced the almost complete abandonment of land and the region suffered a deep and continuous crisis, up to the 1980 decade, when the population decreased up to 11000 inhabitants. From the 1990 decade, the area is experiencing an uncontrolled boom, passing from 700 ha of vineyards to 1500 in the year 2000. Abandoned agricultural land (hillslopes), nowadays naturally re-forested, is being levelled and new vineyards are planted. Large volumes of land are moved and without preserving the original soils. Vineyards are planted on terraces, in crumbled schists. These uncontrolled changes are reactivating erosion processes as well as producing high landscape impacts, due to the clearing of the forest and the terracing of hillslopes. In this respect, the present work raises the hypothesis that present uncontrolled land transformation is not sustainable in the future, and agricultural land could be abandoned in the middle term due to the no refunding of the high investments that are necessary for the creation of new vineyard plantations and the excess of offer in relation to the limited demand of high quality wines produced in the Priorat.

## Erosion processes caused as consequence of the abandonment of cultivation lands in semiarid environment

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The most important reasons for abandoning cultivated lands are the exodus from the countryside and the poor financial returns. Recently, the agricultural policies have increased the surface withdrawn from production. In humid environments, which the rainfalls are abundant and the vegetable cover can regenerate with facility, exercising a protective paper, the abandonment of the lands can be an advantage in relation to the erosion processes. While, in semi-arid environments, where the rainfalls are scarce and the soils are very demoted, the abandonment carries with himself the appearance or reactivation of different erosion processes, that in occasions are so intensive, that let useless lands cultivated in the passed.
In marls soil, with terrace, previously cultivated and that later on, were abandoned, the piping process appears frequently in semi-arid environments. These processes are analyzed in this work, in the semi-arid area of the region of Murcia, where are found in a very advanced degree.
The studied area is located in the basin of Mula, composed predominantly by marls and with a wide development of “badland”. The water-courses were terraced and used as lands of cereal cultivation first, and of almond-trees after in some of them, until approximately the seventies, in those which was produced a progressive abandonment of these fields.
Through cartographic works, of field and laboratory have been located and studied the pipes developed in these fields, being arrived to verify some of its principal causes. Between them, they can be cited: the existence of a hydraulic gradient (high differences between the plots), differences of texture and structure in different depths (slime-clayey, but with more sands content in surface that in depth), presence of salts, high sodium values (higher in depth that in the surface), great proportion of carbon carbonate (about 60%), high change cationic capacity (due fundamentally to the quantity and nature of their clay fraction, constituted preferably by illite and smectite), decrease aggregates stability and scarce content in organic matter, between others.
The characteristics of soils and the not conservation of the terraces, as consequence of the abandonment of these cultivation lands, they are the principal factors, to our judgment, that determine the appearance of the intensive development of pipes in semi-arid environments

## Soil Sealing in the Province of Valencia, Spain. Preliminary Results

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Soil sealing, understood as the covering of soil for housing, roads and infrastructures, is one of the most relevant processes of soil degradation in European countries, not enough known in terms of actual soil consumption and detailed area distribution. The process is not yet well related to the type of soil consumed. In Spanish Mediterranean regions very high land capability areas lay bellow the 100 meters contour line, where in the recent past there has been a large urban, tourism and industrial expansion. The province of Valencia is a characteristic area of such changes.

To study soil sealing in the province, an analytical structure has been implemented integrating all required data in a vector Geographical Information System environment. Basically two different type of sources have been used in the process of data input: digital information from cartographic maps (at an approximate scale of 1:10,000) has constituted the prime source of information from which build up areas and transport networks were extracted.

High definition digital panchromatic orthophotos provided a quick and easy way to revise the information extracted from topographic maps by on screen comparison. Data have been introduced in the GIS environment according to two main thematic groups. One of them responds to the major land cover group of buildings (any class of housing and settlement, industrial, services). The other is concerned with different types of roads (for example, motorways, national, local and private roads), streets and railway networks; although for the present analysis only information on the two major groups is presented herein.

Of the overall area of Valencia (1,081,347 Ha) around 16% (168,529 Ha) lies in the alluvial plains. On the contrary the problem of soil sealing is encountered in larger extent in this smaller zone that lies bellow the 100 metres of altitude. Almost 45% of buildings and communication network are concentrated in the 16% of the territory, being the proportion of buildings (63%) larger than that of roads and other infrastructures (37%).

## Urban Growth Dynamics (1956-1998) in Mediterranean Coastal Regions: The Case of Alicante, Spain

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Among factors causing soil degradation one of the most important, although less studied in Mediterranean environments, is the irreversible loss of soil due to urbanisation processes, inserted into the more general concept of soil sealing. In coastal Mediterranean regions, such us the Comunidad Valenciana, Spain, land cover transformations are mainly produced by contemporary socio-economic changes that have drift from traditional agriculture to industrial and tourism economies. Evaluation of soil sealing is then a key element to understand soil degradation and the disappearance of prime agricultural land.
This work, inserted within a major study on land use-cover change and soil degradation of metropolitan areas in the Comunidad Valenciana, presents the preliminary results on the urban-agrarian dynamics in the municipality of Alicante, the second largest city in the region. Two sets of panchromatic air photos for the years 1956 and 1998 have been used. After air photo scanning, on screen digitising using a base digital topographic map at scale 1:10,000, was applied to extract two types of soil cover: agrarian and urban. A Geographical Information System vector structure has been implemented for cartographic comparison. Finally, to identify spatial and temporal changes maps and overlays together with synthetic tables were produced in order to assess soil degradation.
Results show that there has been a substantial loss of soil devoted mainly to agriculture. Urban growth can be differentiated into three distinct spatial patterns: 1) edge compact enlargement of the city boundaries, including growth following the main road network; 2) compact new urbanisation of alongside the coast and 3) the colonisation by groups of individual residences over in both continental and shore open spaces. One of the main impacts of such new urban pattern has been the loss of the most fertile soils distributed over the alluvial plains around the city, which has been mainly occupied by the tourist and residential buildings.

## Use of economic incentives to enhance soil conservation in the Mediterranean countries: selected case studies

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Land degradation causes severe constraints to agricultural development in general and to environmental quality in particular. The process is largely accentuated especially in developing countries. Previously, land degradation was seen essentially like a physical phenomenon; therefore physical responses and solutions were given.
More recently the socio-economic side of the problem has been acquiring an increasing importance both like cause and response to the problem. It is realized that both degradation process and conservation management are the results of farmer's decisions and that each soil conservation measure must be economically sustainable to be implemented and maintained over long time periods. Often, some specific characteristics of land degradation effects and of land users attributes, require some forms of incentives to achieve and maintain a socially optimal level of land resource conservation.
This poster paper aims to give an overview of the economic incentives, direct or indirect, used in some Mediterranean countries to prevent farmers from undertaking degrading activities and/or to foster the adoption of soil conservation measures. Economic incentives are adopted in the form of subsidies (in cash or in kind) to reduce the cost of the conservation investment and/or those of additional inputs associated with conservation activities including provision of services, like extension, assistance and consultancy; actions aimed at removing existing constraints, etc.
After a brief description of the various types of economic incentives adopted, a tentative evaluation of their effectiveness will be provided. Following relevant guidelines based on a vast amount of international experience, we tried to achieve a better understanding of the reasons and factors that can explain the success or the failure of incentive's implementation.
Basic information for the paper derives from the work being done in the context of the MEDCOASTLAND Thematic Network activities that will be operational until 2006. The Network includes 13 countries from southern Europe, North Africa and the Middle and Near East. Among several objectives of the MEDCOASTLAND Project, the socio-economic aspects of land degradation and especially economically driven solutions to halt degradation and generate income for poor-resource farming communities is of paramount importance.
Extensive research and experience in soil conservation management is available in almost all the countries participating in the Network. The poster will show some practical examples from projects in Morocco, Jordan and Turkey. They make evident the problems and possible solutions offered to the farmers of the areas involved in those projects.

# TOPIC 3:
# SOIL AND VEGETATION MONITORING TECHNIQUES AND PROGRAMS

## Soil Mineralogy Effects on Runoff and Soil Erosion

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Soil erosion and runoff are serious and widespread land degradation problems that could cause a desertification. This issue is particularly acute in the Mediterranean region because both climate (irregular but intense precipitation and drought events) and socio-economic (high rural depopulation rate) conditions, which make this region highly susceptible to flooding, drought, wild fires and erosion problems. These problems are expected to increase in the future due to climate change: rainfall events will decrease in frequency and increase in intensity. Interaction between clay particles is one of the main factors responsible for soil aggregation. Therefore, soil mineralogy, which has substantial effects on clay dispersion, may also influence aggregate stability, seal formation, runoff and soil loss. In spite of this, the effects of soil mineralogy on these phenomena have received low attention in the literature. This paper reviews the effects of soil mineralogy on aggregate stability, seal formation and micromorphology, and on the associated infiltration rate (IR), runoff, and soil loss. Various soils with different mineralogy were collected from many regions. In these soils, the aggregate stability was determined under fast wetting conditions, and the IR and the interrill soil loss were determined using rainfall simulator. Clay mineralogy was found to be a dominant factor in controlling aggregate stability, seal formation, soil IR, and interrill soil loss. The phyllosilicate soils, divided into two main groups: (i) stable soils with final IR > 8.0 mm $h^{-1}$; and (ii) unstable soils with final IR < 4.5 mm $h^{-1}$. These two soil groups differ in their mineralogy. Kaolinitic and illitic soils that do not contain smectite were stable soils, and less susceptible to seal formation. In contrast, kaolinitic and illitic soils that contain some smectite, and smectitic soils were unstable. Examination of the susceptibility of 21 phyllosilicate soils to interrill erosion indicated that these soils could be divided into three groups. Soil loss was higher for unstable soils than for stable soils, but the soil loss of the smectitic soils was significantly higher than that of the unstable soils which contained kaolinite or illite as the dominant clay.

## Some consequences of desertification on soil fertility and food security

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The aim of our work was to see in model experiment how the growth of plants and their nutrient uptake decreases in water deficient conditions and how the security of yield will be influenced by such conditions. The other purpose was to measure the change of element sorption ability of soils after removing the most active part of the humus content.
First the soil samples were digested with $H_2O_2$ to remove some part of the organic matter. Both the original and treated soils were shaken with a bright concentration range of Cu, Zn, Cd and Pb ions, respectively for the determination of the rate of ion sorption. Desorption was carried out on the soil of the 1000 $mgkg^{-1}$ treatment. Not only were fewer heavy metal ions (Cu, Zn, Cd, Pb) adsorbed after the removal of organic matter, but the adsorption energy of the ions was also far smaller than prior to organic matter removal. On non-calcareous soils more heavy metal ions were desorbed from the fewer adsorbed ions in all cases than prior to organic matter removal.
Pot experiment was established in climate chamber with 8 kg sandy soil at two soil moisture contents (pF 2.0 and pF 3.7), with 3 soil phosphorus levels using maize as test plant. All the growth parameters (root and shoot growth, leaf surface area) were positively correlated with the moisture content.
In another pot experiment with spring barley also the same two soil moisture levels and two phosphorus levels were set up. Moisture content of the soil has a major role in P-acquisition by its effect both on the transport in the soil and on root growth and uptake.
It could be concluded that the production of secure amount of yield and proper nutrient content require satisfactory moisture level in the soil during the vegetation period. On other hand when the desertification is in progress and the soil step by step looses the most active part of its humus content, the previously adsorbed toxic heavy metals become more available and could cause unfavourable effect on the quality of yield.

## Land resources degradation optimal management model application in Armenia

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Econometric study of land resources degradation is rather new phenomenon and one of its features is its application mainly for developing countries cases because of the dangers of losing the land and desertification severeness. In this sense Armenia is not an exception to the rule and according to our observations, there are numerous cases of agricultural land degradation due to suboptimal productions. In our opinion econometric study of land resources degradation answers two important questions: 1) how can the changes in agricultural products prices affect the attitude of producers towards land resources degradation and their economic activity?, 2) what is the role of physical and economic interlinkages in evaluation of economic loss because of land resources degradation.

Model presents a farmer whose objective is to maximize his product. His decisions are partly dependent on the quality of land which, in its turn, is dependent on agricultural activities of previous years. So the farmer seeks to find the optimal level of land resource or loss of land's quality. The depth (X) of land's last layer (humus) and the level of organic agents (Y) are phase variables whose values are determined based on the selection of crop type of the previous time period, especially on the crop areas of grain crops (U). The dynamics of X and Y variables is descripted by the following equations (which contain a and b coefficients) – the so-called loss functions: $X_{t+1}=X_t-a(X_t, Y_t, U_t)$, $a>0$

$$Y_{t+1}=Y_t-b(X_t, Y_t, U_t),\ b>0$$

The agricultural product progressively declines as the result of land upper layer and quantity of organic agents reduction. It follows that with given prices and without additional investments (like addition fertilizing for restoring lost resources) the profitability of grain is a declining function of U. The objective of a farmer is to choose such a $U_t$ for each time period so as to maximize the profit (G)

$$\sum_{t=1}^{\infty} G(X_t, Y_t, U_t)\frac{1}{(1+r)^t}, G_u > 0$$

r – is the discount factor. Further development and extension of the model for Armenian economy is to be based on the study of interlinkages between agriculture and other sectors of the economy.

## Impact of Forest Fires on Hydrological Properties of a Typical Mediterranean Forest Soil

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Fire is one of the most important determining factors in the evolution of the Mediterranean ecosystems. Their effects on soil are plural and diverse, acting on structure, chemical and physical properties, biota etc. Among them, the induced variations on soil water dynamics are of key importance for the recovery of the entire ecosystem and in the soil response to erosion processes.

Effects of fire are not only limited to biophysical impacts, but it also has socio-economic consequences. Fire produce the degradation of wide areas of forest and, by the other hand, raising substantial losses on economic resources and, sometimes, in human lives.

These facts acquire capital importance in the Mediterranean basin where, in many cases, the maintenance of the population in forest or rangeland areas depends on the sustainability of limited resources and the preservation of a fragile water balance. In addition to that, the increasing frequency of fires in the last decades has decreased the regeneration possibilities of the ecosystems and favoured the advance of desertification.

In this context, the aim of this study is to assess the effect of the impact of different fire intensities on soil hydrology and its effect on runoff generation. The work was developed in la Concordia Experimental Station with nine plots (4 x 20 m), installed in a calcareous hillside representative of Mediterranean shrubland areas. Experimental fires, of two intensity levels were carried out. Three plots were burned reaching high fire intensity, other three plots were burned moderate intensity and the remainder plots were left undisturbed as control. Soil water content, water retention capacity and pF curves were measured together with runoff generation dynamics, in the different plots. The intrinsic characteristics of each rain event occurred until a year after the fires and runoff generated on them were monitored.

During the reporting period 24 rain events with runoff generation occurred, with average rainfall intensities ($I_{30}$) around 10mm $h^{-1}$. Both fire treatments show significant differences respect to the control plots, which are reflected in a value of runoff production in the last ones of 76.84%, as an average, minor than the burned plots. Between fire treatments, the plots burned with high intensity show the highest values. However, infiltration rates do not give significant differences between fire treatments.

In the same way, plots that suffer a high intensity fire show greater values (114.43 mm) on water retention capacity than the other treatments, giving significant differences with the moderate intensity and the control plots. Differences on this parameter between plots burned with moderate intensity and the control ones were observed, but they were not statistically significant. The obtained pF curves show the same tendencies, being the greater water content retained at pF water of 2-2.5 in the burned plots and in the control ones at pF of 3.5-4.2.

The effect of fire degrading the vegetation cover and the temperature impact on soil, produce changes in its structural characteristics and porosity, affecting soil water distribution and the resilience of soil to water erosion processes.

## Influence of Durum Wheat–Field Pea Cropping System at Different Nitrogen Fertilization Rate on Soil Organic Carbon in Sicily

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Dry areas desertification preservation mainly depend on soil carbon level control, maintenance and improvement. In the last century, high input cropping systems (tillage system, nitrogen application, monocropping wide use, etc.) determined both high production but also a strongly soil carbon decay due to a continuous native soil organic matter intake.
With the aim to monitoring effects of cropping system and fertilization rate on soil organic matter evolution, two different cropping systems (Durum wheat monocropping and Durum wheat-field pea) typical of the Sicilian inland rainfed areas, were tested along a six-year trial, in interaction with three nitrogen fertilization rate (0, 60 and 120 kg $ha^{-1}$) in relation to the main soil chemical parameter: total N, Soil organic Matter, Mineral N, PMN (potentiality of mineralization of nitrogen), on two soil layers (0-15 cm and 15-30 cm); soil carbon fluxes were also measured after seed bed preparation.

## Organic Matter and Aggregate Size Interaction on Soil Structural Changes and Hydraulic Properties

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Runoff and soil erosion are two of the main land degradation processes which lead to desertification in the Mediterranean region, and these problems are expected to increase in the future due to climate change. Thus, there is a clear and urgent need to study the soil properties controlling runoff generation with the objective of implementing effective measures to prevent soil loss. In arid and semiarid zones, runoff is the result of the formation of a seal in the surface of the soil under the impact of the raindrops. This process is directly related to the soil aggregate stability, which depends on soil properties like clay content, clay mineralogy or organic matter (OM) content. Desertification will carry a decrease of OM in the soil due to: i) a decrease of the input of plant debris, ii) an increase of OM mineralization by microbes due to the increase of temperature. The objective of the present paper was to investigate the effects of the decrease of OM and its interaction with aggregate size on the hydraulic properties of the soil: saturated hydraulic conductivity ($K_S$) under no raindrop impact, and infiltration rate (IR) under raindrop impact and sealing conditions. These properties were studied in a sandy loam soil (Humic Dystrudept) with two different levels of OM content: 2.3% and 3.5%, and with three different aggregate sizes. $K_s$ values of the high OM soil were, in general, significantly higher than of the low OM soil in each aggregate size. Moreover, there was a significant interaction between the aggregate size and the OM content in their effects on the $K_s$. The results suggest that the degradation of the soil structure occurred in more extend in the low OM soil. Under rainfall conditions, IR decreased as the cumulative rainfall increased due to seal formation at the soil surface. The low aggregate stability and the high dispersivity of the low OM soil allowed the breakdown and dispersion even of the largest aggregates. Consequently, a dense and thick (>1 mm) crust was developed for all the aggregate sizes. In contrast, the high aggregate stability and the low dispersivity of the high OM soil limited the breakdown and dispersion of the aggregates at the surface, and therefore, the IR values were high and runoff and soil loss low.

## Physiological Aspects of *Sesuvium Portulacastrum* Responses to Salinity and Drought

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*Sesivium portulacastrum*, a perennial dicotyledonous halophyte from the family of Aizoaceae, is a fast growing plant and can cover large areas when irrigated with saline water. This property confers to this species high ability of protecting and fixing soil. Other studies recommend, however, utilisation of *S. portulacastrum* is landscaping and for ornamentation activities. The aim of this study is to analyse its behaviour under salinity and drought constraints.
Two experiments with different sets of cultures were achieved. In the first, aimed at determining the limit to salt tolerance, young plants were grown on pots containing inert sand and irrigated with nutrient solution enriched with NaCl at concentrations ranging from 0 to 1000 mM. In the second experiment, plants were grown on pots containing an agricultural soil and irrigated with town water at 100, 50 and 25% of the field capacity. In the end of treatments, Biomass production, tissue hydration, $K^+$, $Na^+$, $Ca^{2+}$, $Cl^-$ and proline concentrations in tissues were measured.
Results showed that this specie is able to maintain high growth potentialities up to 400 mM Na Cl in the medium. Above this concentration, a significant growth reduction was observed, and was associated with $Na^+$ and $Cl^-$ accumulation and tissues impoverishment of $Ca^{2+}$ and $K^+$. An experiment with a split-rooting system showed that NaCl induced decrease pf growth resulted from indirect salt effects (restriction of $K^+$ and $Ca^{2+}$ uptake) rather than that direct salt effects (high $Na^+$ and $Cl^-$ accumulation in tissues).
*S. portulacastrum* is also tolerant to drought and can find its growth potentialities after a severe water shortage. Proline seems strongly involved in the *S. portulacastrum* tolerance to osmotic constraints.

## Soil Chemical Base of Soil Sustainability to Technogenic Desertification And Ecological Consequences of the Environmental Pollution

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Technogenic desertification is a global event at last dozens of years. It has local spread, depends on the level of technogenic development of the region and it does not attached to the separate climatic zones. Technogenic deserts can appear in those cases when the load of pollutants which are connected with the wastes of industry and energy plants or transport exceed the natural sustainability of correspondent landscapes to pollution. Soil is the main component of ecosystem and environmental sustainability to pollution has soil- chemical base. The properties of soil components ensure the quality of pollutants (heavy metals, oil products and others) retained by soils and the strength of their fixation. The same factors provide the danger of polluted soils to plants and ground water. The change of the local pollution into regional dissimilation of pollutants is tightly connected with soil properties too.

There were analyzed the soils of the technogenic deserts, which are located around the nonferrous plants of three regions of Russia (Kola Peninsula, Far East and Middle Ural). The common and specific features of the influence of chemical state of soils on their sustainability to pollution in these regions are discussed. There were formulated the ecological and methodological issue about soil-chemical base of the assessment and forecast of the local technogenic desertification connected with pollution in different natural regions. The specific features of the influence of the chemical properties of Mediterranean soils on their sustainability to technogenic desertification, provided by pollution, are discussed.

## Fire and Sediment Production in two Prepyrenean Forest Basins (Aragón, Spain)

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The fire introduces important environmental changes; without a doubt, most impressive it is the degradation of the vegetal cover and, as a result of it, a highest soil erodibility, increasing the rates of soil losses in the stage post-fire.
The fragility of certain Mediterranean areas, based on factors such as slopes, shoft and uncovered outcrops or determined activities in the period post-fire -wood extraction, reaforestation- causes that the consequences of the fires are extended along the time.
During August of 1994 it took place a fire that devastated 2000 hectares of forest surface, affecting to a great area of the basin of the Alastuey river and to a reduced sector of the nearly Real river (Sierra of San Juan de la Peña, PrePyrenean Ranges). The location of two gaugings in the lowest sections of both rivers and the collection of data of sediment in suspension, simultaneously (1996-2000) and after the reaforestation activities (2000-2003), have put in evidence the different behaviour from both basins of similar characteristics, although, in the situation pre-fire, the basin of Alastuey river already presented a greater environmental degradation in relation to a highest erodibility.

## Physical and Hydrological Soil Properties as Indicators of Desertification Processes along a Mediterranean Climatological Transect in the South of Spain

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The South and Southeast of Spain are one of the European areas affecting by the desertification processes. Most of the cases, desertification is joined to the burst agent, therefore with hydrological erosion processes. Unquestionably, these soil particles movements generated processes lead to important changes of some properties. Such changes can generate modifications in soil hydrology with a soil productivity loss and consequently a vegetation cover reduction, favouring the soil erosion processes what have been termed feedback processes, which final will be the appear of irreversible situations. Mainly, such soil properties are aggregate stability, clay, organic matter, soluble salt and carbonate content.
The investigation boards the study of the mentioned processes through the methodology of the analogue situations reproduction in the South of Spain (Bethics Chain). They are areas with metamorphic rocks (schists and filithes), high slope gradient and very shallow soils due to a historical management in the most of the cases. It is defined a climatic gradient at this area, which fluctuates from 600 mm at Almogia (ALM) and 480 mm at Campanillas (CAM) to 400 mm at Albuñol (ALB). We have selected a representative slope with a similar exposition and length in every one of each area. The soils and hydrological properties was analysed every 9 m along the slope length from the top to the bottom.
The final results show that there are modifications in the soil and hydrological properties studied with the increasing of aridification, and the protector role of vegetation cover too. Such changes suppose the soil degradation what make us to suspect the existence of desertification processes. Furthermore, we can reject such changes do not produce along every slope in the same way, so the inside variability slope becomes other interesting investigation way to analize, specially to determine the connectivity processes along the slopes.

## Minimizing Desertification by using Appropriate Soil Tillage

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Water and soil conservation are most important in preventing land degradation and loss of productivity in semi-arid regions. The development of appropriate tillage system on the fragile soils from semi-arid regions is critical to prevent desertification. The pulverizing action of conventional tillage (CT) used in the region is responsible, in part, for the high erosion. However, in spite of the many studies on the effect of no-till (NT) on soil's structure and the hydraulic properties of soils, there is much disagreement about the benefit of this management. Whereas in many studies, NT was found to increase rain infiltration and decrease erosion, there are as many studies where no beneficial effect of NT was observed. We hypothesized that the beneficial effect of reduced tillage depends on soil texture. Only in soils with >30% clay, no tillage and aging (time since cultivation) may improve soil structure and reduce runoff and erosion. This hypothesis was tested on 12 soil samples that were collected from neighbouring fields under CT and NT management. Saturated hydraulic conductivity (HC), under fast and slow wetting rate (WR), was determined. In silty loams (15 and 25% clay), the WR had no effect on the HC of the soils, and no difference in HC between the NT and CT samples was measured. In soils with > 40% clay, the saturated HC of the NT samples was 3-4 times the HC of the CT samples and the HC of the NT samples decreased sharply with an increase in WR. In the NT soils there were more stable aggregates, which disintegrated by fast WR. The HC of the soils with <25% clay were not affected by WR and NT. Soils with intermediate clay content had HC values that were slightly affected by WR and NT. In soils from semi-arid regions with low organic matter content, the clay act as cementing material stabilizing aggregates. Clay content in the silt loams is too low for aggregate stabilization and no beneficial effect of NT is possible. Only in clay soils, there are stable aggregates whose HC is affected by WR and NT and aging has the potential to improve aggregate stability and minimize desertification.

## From Mediterranean to Desert Ecosystems: An Experimental Approach for Studying the Effects of Global Climate Change on Plant Community Dynamics.

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Natural climatic gradients, which are represented by changes in environmental conditions such as altitude, temperature and rainfall, provides an excellent framework for studying the effects of climate change on the factors that regulate the structure and functioning of ecosystems. Particularly, the short distance - strong climatic gradient in Israel, provides an excellent opportunity to test predictions regarding the effects of global climate change on ecosystem functioning and desertification processes. This climatic gradient runs from mesic Mediterranean ecosystems in the North to arid desert ecosystems in the South.

The rationale, methods and objectives of a novel experimental study on the effects of climatic manipulations on the structure and function of plant communities along an aridity gradient are presented here. Climate change scenarios are experimentally tested with manipulations of rainfall amount using rainout shelters and irrigation systems. The investigation includes changes in plant community and population characteristics, such as soil seed bank parameters, primary productivity, community composition and structure, species richness and diversity, together with litter decomposition processes and important soil characteristics. Comparison of natural communities between sites along the climatic gradient can be used as analogues of climate change within manipulated sites. Results from the first two years of the study will be presented.

## Modelling Soil Erosion in Central Greece

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Soil erosion has been studied in the Viotia area, Central Greece. An integrated approach has been adopted based on portable rainfall simulator studies, on data from a permanent experimental field and on the Cs-137 technique. The ultimate aim is to develop the pedotransfer functions to construct a simple erosion model based on the Revised Universal Soil Loss Equation (RUSLE, Reynard et al., 1987) in order to predict soil erosion for Mediterranean conditions on the field scale. A portable rainfall simulator similar to that described by Bowyer-Bower and Burt (1989) has been used in order to investigate soil responses to rainfall intensities of eight different soils in the Viotia area. Ponting time was recorded and runoff and sediment yield were monitored for thirty minutes after ponding, while sediment yield and runoff water were analysed for nutrient N, P, K content. An experimental erosion field with nine plots of standard 22 m length (Morgan, 1979) and slope about $7^o$ was established and three treatments were studied, i.e. winter wheat, fallow land and bare (herbicide treated) land. The Cs-137 isotopic technique has also been used in order to estimate long-term soil erosion by defining the Cs-137 profile percentage residuals in relation to the local Cs-137 input inventory. Rainfall simulator data show a high variability even in the same field and with the same rainfall intensity, also between fields in runoff initiation time, in the total sediment yield and in the total runoff. This is probably due to soil complexity, scaling and spatial variability. With rainfall intensity of about 80 mm/h and with a duration of 30 min after runoff initiation, it was found that the ponding time in the eight (8) fields studied varied from 1.66 to 12 minutes. The percentage of the rainwater washed away varied from 30 to 71% of the rainfall. The soil erosion rates varied from 1.05 to 3.78 tn/ha. The nitrates in the runoff varied from 1.736 to 19.528 kg/ha. The total K measurements in the runoff water varied from 0.627 to 1.976 kg/ha while the P concentrations from traces to 66g/ha. The permanent experimental field runoff and sediment yield data of the experiment showed a high variability during the growing period. This probably depends of the rainfall pattern and intensity as recorded by the rainfall gauge and the stage of vegetation growth. Indicative measurements for a period of 43 days in early spring (March-April) 1999, with 96 mm recorded total rainfall were total runoff rates varying from 1.19 $m^3$/ha in the fallow land to 1.4 $m^3$/ha in the wheat and 2.37 $m^3$/ha in the herbicide treated land. The soil erosion rates for the same period were 5.23 kg/ha for the wheat 1.89 kg/ha for the fallow land and 2.77 kg/ha for the herbicide treated land. Based on Cs-137 residuals the erosion and deposition rates in a catchment were estimated using the simplified mass balance calibration models developed by Walling and He (1997). Erosion rates in the studied catchment varied from 6.71-85.55 $tha^{-1}y^{-1}$ with an average lose of 18.34 $tha^{-1}y^{-1}$.An erosion model is developed to describe and predict single event or annual soil erosion rates under Mediterranean conditions on the field scale, based on the Revised Universal Soil Loss Equation (Reynard et al., 1987) for sheet erosion. This was developed with the use of SB Model Maker, software (VERSION 3.0). The model is being calibrated for local conditions and validated using sensitivity analysis facilities and rainfall simulator data. With existing soil survey data and the outputs of the model incorporated in the G.I.S. at the soil mapping unit level, the S oil Erosion Map of Viotia has been produced.

## Post-fire Restoration to Combat Desertification in Mediterranean Climate

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Wildland fire is a major disturbance promoting landscape changes and triggering desertification processes in the Northern Mediterranean basin. Addressing that issue in the long term requires both fire prevention and post-fire restoration measures. Post-fire restoration should mitigate ecosystem degradation, and improve ecosystem regeneration rate and quality.

The impact of wildfires is especially acute in the transition between semi-arid and dry subhumid climates, where dry vegetation fuels facilitate fire spread and water shortage limits post-fire regeneration. In addition, the high occurrence of torrential rains produce a high risk of post-fire flash-floods, especially in autumn after summer fires.

The major objectives of post-fire restoration are soil and water conservation and increasing ecosystem resistance and resilience in front of fire. Post-fire restoration strategies are defined according to the degradation stage of the ecosystems, and the recovery capacity of vegetation. Plant cover regeneration rate highly influence post-fire soil erosion and flooding risk. The abundance of woody resprouters is recognised in eastern Spain as a critical factor to ensure an efficient recovery of plant cover after fire.

Post-fire restoration planning is addressed taking into account vegetation fragility to wildfires, together with soil erosion risk and soil moisture availability (physical features). Vegetation fragility is defined both in relation to spontaneous regeneration capacity of plant cover and in relation to the ability of keystone woody species to persist after fire. A synthetic indicator to assess wildland protection and restoration priorities in relation to wildland fires is developed by combining vegetation fragility and physical layers in a GIS.

## Temporal Evolution of Soil Roughness in Areas Subjected to Channelled Erosion

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Soil erosion is one of the most causes of desertification in the Northern Mediterranean. Recently the role of channelled erosion in sediment delivery has been underlined by different experimental researches. The aim of the present work is to set up a simplified experimental methodology to study the dynamics of the process by monitoring temporal evolution of soil roughness along the slope.
The experimental plot is located on a steep slope in a hilly area of Central Eastern Sardinia, where intense agropastoral activities, particularly tillages and other activities realised with heavy machinery, are causing severe soil erosion and compromising agricultural productivity. Precedent studies carried out in the same area highlighted the need to quantify and monitor soil erosion to be able to give the farmers clear management guidelines.
The adopted procedure was based on the recording of altitudinal variations of soil surface along two couples of transects 14 meters long. In each couple, the two transects were parallel to the contour lines and about 15 meters far from each other. Measures were taken every 10 cm along the transects by using a vertical graduated pole. The two slopes show different slope angle and concavity, both are characterised by several sub-parallel rills.
Five sets of measurement were collected in October 2001, March, May and October 2002 and in May 2003. During the experimentation meteorological parameters were recorded by a meteorological station located near the plots.
To quantify surface roughness statistical and fractal techniques were used. A roughness index was calculated at different scales. The Richardson plot was drawn for each profile and the fractal dimension was estimated by linear regression. The significance of the regression was verified by the high value of $R^2$, mostly greater than 0.95. The total soil loss was also estimated, by referring to the temporal variation of the average value of the surface level along each transect.

The research was carried out within the DesertNet project, an INTERREG IIIB – MEDOCC initiative involving ten Mediterranean Regions. The experimental activity was a part of the pilot action of the partner “Regione Sardegna”

# TOPIC 4:
# WATER RESOURCES AND MANAGEMENT

## Effects of Soil Management (Organic *vs* Conventional) on Water Retention and Drainage in two Horticultural Crops in Valencia

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The overuse of groundwater in the coastal Mediterranean region is lowering aquifer's levels. Water use efficiency optimisation is a major need in these regions. A one year field experiment was conducted in the area of Valencia in an organic farm and a conventional one. The crops compared were lettuce (Autumn season) and potato (Spring season). Water inputs from rain and furrow irrigation were measured as well as soil wetness to 75 or 80 cm depth, in selected periods. Crop ET was calculated using reference evapotranspiration and crop coefficients; internal drainage was calculated through water balance. Furthermore, water use-related soil properties such as bulk density and organic matter content were determined as well as the water release characteristic curve. The volume of irrigation water applied and of drainage was lower for both crops in the organic system without showing a lower yield. Soil water release curves showed higher macropore proportion at the lower depth analysed and greater storage micropore volume in organic plot. These facts are supported by higher levels of organic matter in the organic farming system and allow a better internal drainage. Bulk density didn't show significant differences between the two systems. This study shows that organic farming in the Valencian area could contribute to a better use of water resources.

## Changes Induced by NaCl in Lipd Peroxidation and Antioxidant Enzyme Activities of Oleaginous Halophytic Plants: *Crithmum Maritimum*

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Activated oxygen species (AOS) that are inevitably produced as byproducts of oxygen metabolism have deleterious effects which cause cellular damage. As do other aerobic organism, higher plants have active oxygen-scavenging systems consisting of multiple defence enzymes such as superoxide dismutase (SOD), ascorbate peroxidase and Catalase. The possible involvement of the antioxidate system in the tolerance of salt stress was studied in the oleaginous halophyte: *Crithmum maritimum.*

Sterilised seeds of *Crithmum maritimum* were germinated in Petri dishes for 9 days. Then, seedlings were grown hydroponically in nutrient solution under cycles of 16 h light at 28ºC and 8 h dark at 25ºC in a plant growth chamber. One month aged plants were divided in 5 lots and submitted to increasing NaCl concentrations: 0, 50, 75, 100 and 150mM. The measured parameters were growth (FW, DW), water content, ionic status, MDA levels and antioxidant enzyme activities.

Our data show that:

i. *Crithmum maritimum* expressed its maximal growth potentialities at 50mM NaCl. Nevertheless, this specie is able to survive high NaCl concentrations (up to 300mM)
ii. MDA content in leaves is low. The lower level of lipid peroxidation suggest therefore that plants are protected against oxidative damage under salt stress.
iii. The highest specific activities of SOD (superoxyde dismutase), CAT (catalase) and POX (peroxydase) are measured in leaf extracts of plants subjected to 50mM NaCl.
iv. Separating leaf extracts of plants grown under salt conditions by non-denaturating PAGE and staining for SOD, CAT, POX, APX and GR activities revealed distinct isoformic bands. SOD, CAT and POX isoforms were induced in vitro at 50mM NaCl. Some of these isoforms were lost at NaCl concentration above 100mM NaCl. The isozyme patterns of APX (ascorbte peroxydase) and GR (glutathion reductase) did not change significantly.

The capacity of plants to enhance the activity of the enzymes involved in the defence against oxidative stress seems to be important in determining adaptation to moderate NaCl stress conditions. In plants experiencing severe NaCl stress (150-300 mM), it seems that such resistance to oxidative stress is overcome, which might contribute to the deleterious effects of salt and significant growth reduction in these conditions.

## Monitoring Soil Water in the Vadose Zone

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Detailed soil water content measurements are required for many applications in different subjects such as agronomy, climatology, meteorology and biogeochemical cycles. Nevertheless, from both the operational and economic point of view, it is unfeasible to obtain soil moisture time series at many locations with a fine vertical resolution along the profile. New soil moisture sensors based on soil dielectric measurements are commercially available nowadays but one of the main inconvenients of this type of sensors is that they have a very localised sphere of influence, which can create difficulties for monitoring the integrated water content of a soil profile, particularly when there are large short-range variations in soil water content. The aim of this work is to develop interpolative techniques to combine occasional measurements of soil water content at a large number of depths/locations with continuous records from a limited number of depths/locations to enable estimation of: a) The integrated water content of the profile, and how it changes with time; and b) The detailed vertical distribution of water, and how it changes with time.
Detailed measurements of the vertical distribution (2 cm depth resolution) at a number of locations in the field on 14 occasions during the growing season revealed that there was large spatial variation in the vertical patterns of water content, due to variations in the localised sphere of influence of the sensors. Except during periods where there were steep vertical gradients in matric potential, there was a strong temporal stability in the vertical distribution of relative water content. This provided the basis of a technique for the vertical interpolation of continuous records at a few selected depths (3, 10, 20, 30, 40, 60 y 100 cm depths) based on the occasional information available at 2 cm depth resolution. This enabled the interpolation of a 2 cm depth resolution, 30 minutes time resolution data-set of soil water content at each location.

## Anthropic Salinization of New Irrigation

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The Tagus-Segura water transfer declared the Pedrera region (Alicante province, south-east Spain) a priority area for new irrigation. In 1974 a detailed ground study was carried out with the aim of selecting 7,500 hectares out of the region's total of 29,070, all belonging to Types II and III according to USBR regulations.
Due to the suitability of the climate and the profitability of the crops, the area selected for irrigation will be increased to a limit of 13,000 hectares, thereby reducing the relevant amounts of irrigation water relative to those assigned in the preliminary study.
After 25 years of insufficient irrigation over these 13,000 hectares, it is hoped to evaluate the impact on soil characteristics implied by this increase in the surface to be irrigated without a parallel increase in the amount of water assigned to the area.
To this end a new detailed ground study has been drawn up selecting the same land profiles studied at the time of the change. 39 observations, 11 profiles and 28 boreholes have been examined, analysed and characterised, and these, we repeat, have been made to coincide with those same enclaves that were studied 25 years ago.
The analysis shows generalized salinization in 22 of the 39 observations studied, with saline soil characteristics being observed with values in some cases over 14 dS/m.
The reason for this anthropic salinization is the use of dubious quality water from various sources which, during the course of these 25 years, has been supplementing the insufficient amounts of good quality water from the Tagus-Segura transfer.
The non-application of the measures recommended in the basic irrigation start-up study - in which the irrigable surface area was limited to 7,500 hectares and irrigation doses were recommended which included an amount for cleaning and, in some physiographical positions, drainage systems - is the reason why 22% of the irrigation area is no longer able to be used as originally planned. The original uses included, for example, the growing of citrus crops, which today have all been pulled up and substituted by crops more resistant to salinity, such as pomegranates, figs, palm trees and cotton.

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## Available Water Capacity of a Soil Amended With Composted Sludges and Affected by Simulated Processes of Soil Degradation

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Under dry Mediterranean climate, water erosion and wildfire cause a continuous degradation of the soil organic matter and the soil structure. These effects, normally, were avoided with the organic amendment of the soil surface. To model these relationships, the relative available water capacity index (RAWCI) of a coarse-textured forest soil classified as Rendzic Leptosol have been investigated in representative soil samples of Zarra (Valencia, Spain).
Under laboratory controlled conditions, soil samples amended with three doses of composted sludges (0, 5 and 10 %) were subjected to three levels of energy of the simulated action of water erosion (E0, E1 and E2; respectively 0, 100 and 600 J/ml) and at two levels of heat–induced intensity (F0: 25 ºC and F1: 500 º C of maximum temperature on the soil) in a randomised completed block experimental design. For all treatments the relative indexes of the available water capacity (percent of variation by reference to the value of the control treatment) and the proportion of macroaggregates/ microaggregates in the soil were calculated. For the successive highest level of simulated degradation processes (i.e.- the combination of treatments E2 F1) the RAWCI increased 5.3 % without organic amendment and 21.5.0 % with the highest dose.
In assays without and with heating (F0 & F1) the level of water erosion significantly increased the RAWCI of the soil samples. The amendment of this loamy sand soil at the rates of 5 and 10 % (w/w) diminished the breakdown of macroaggregates into microaggregates provoked by the water erosion, but their soil organic matter (SOM) decreased more slowly than in the unamended soil. As a consequence the SOM in the unamended soil was concentrated around the particles of fine sand and that would provide more their combustion by the heating induced treatment than for the amended soil samples. This fact selectively affected the RAWCI of the soil with a bigger increase for the amended than for the unamended soil samples.

## Effects of Soil Use on Topsoil Water Content in Plots of the North Side of the Mediterranean Region (Ne Spain)

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In the Mediterranean area the precipitation amount is irregular throughout the year irregular too between years. Usually rainfall is important in springtime and autumn and frequently it rains in winter too. In the firsts period of the springtime the water consume is relevant and plants consume water from the soil water reserve. The water consume from the soil is based on the upward water flux from the soil profile. In this case the topsoil horizon is a relevant interface between water reserve, atmosphere and plant roots. This effect is important to cultivated plants, abandoned lands and forested areas.
The aims of this papers are the results of the monitoring the topsoil water content in plots of the three different soil uses throughout five periods (1994 to 1999) from February to May. The soil uses are: conventional tillage of a leguminous – cereal rotation; abandoned land (since 1994) and a forested area (pinewood since 1950).
Three plots with an extension near of 2 500 $m^2$ are located on an 8% slope south faced and soils are Calcic Cambisol type. In each plot two vertical TDR proves are placed. TDR and rainfall data are weekly recorded. The soil use has a relevant influence on topsoil water content and the upward water flux is affected by the type of soil use.

## Evaluation of Drought on the Territory of the Republic of Moldova

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The most part of agricultural lands of the Republic of Moldova is located on the territory with insufficient moisture. The continently of the climate is a prerequisite to drought frequency. The drought is a complicated phenomenon. It is a combination of the insufficient precipitation and high evaporation that leads to considerable decrease in yield.
Many investigators represent the drought degree as the decrease in yield of cereals (%) with respect to the average yield during the past 20 years. They distinguish the following types of drought: weak drought and conditions close to drought -decrease of yield by 20 %, intense drought - 20-50% of losses, and very intense - over 50 %. Drought losses are not easy to determine. There are a lot of other causes leading to the decrease in yield, which are as follows: mass injury of plants by diseases and pests, rain showers, hails etc.
To evaluate drought phenomenon on the territory of RM the aridity degree has been calculated. For calculation the historical data (1890-1999) on quantity of precipitation have been used. (The data have been offered by the State Hydrometeorological Service). Thus, the precipitation and temperature total per year were determined. But for making good use of aridity degree the evaporation capacity must be determined.
There are various methods to calculate evaporation capacity. One of which is to use historical data on evaporation capacity offered by the State Hydrometeorological Service, however the data are incomplete. And therefore, a decision was taken to use method by Oldekop. For this purpose the historical data for 1950-1999 on vapour pressure was considered and vapour pressure total per year was determined. For calculating evaporative capacity, vapour pressure must be multiplied by 19.35. The results of the aridity degree are presented in the table below.

**Aridity degree on the territory of Republic of Moldova**
**Aridity degree = R/E**
Period of observation: 1950-1999 (April – October)

| Region | Precipitation (mm) R | Evaporation capacity (mm) E | Aridity degree |
|---|---|---|---|
| **North** | 628 | 676 | 0,93 |
| **Centre** | 533 | 893 | 0,60 |
| **South** | 428 | 886 | 0.48 |

Also, it is necessary to make up the map of drought on the territory of RM, on basis of obtained data on the aridity degree (table). According to the map of drought on the territory of RM, the North of the country located in the humid zone, but Central and Southern parts belong to sub-humid zone. And therefore, Central and Southern parts of the country can be subject to desertification.

## Soil and Nutrient Removal by Water Erosion in Terraced Soils under different Land Use

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The influence of minimal agricultural management and various plant covers related to the period of abandonment on soil properties, erosion and nutrient depletion in a typical Mediterranean area with sandy loam shallow soils was investigated. Cultivated terraced soils (CTS) with insufficient management, 5 year abandoned soils covered with meadow (M5), 25 year abandoned soils covered with dense scrubs (S25), 50 year abandoned soils covered with cork trees (CT50) and soils in a 50 year pine reforested area (P50) were studied over a period of one year (January-December 2001). The soils were classified as Lithic Xerorthents. Both the differences in soil properties and response to rainfall events were mainly attributed to the different vegetation types and stages in land management. Principal components analysis (PCA) was performed on the results, by running the overall data determined after 11 rainfall events. The factors extracted by PCA of the samples by variable matrix represented the response of the environments to different rainfall intensities as a function of management or natural evolution after abandonment. CTS environments showed the highest runoff and sediment yield as well as the highest amount of dissolved organic carbon (DOC) and nitrogen in runoff water. The sequence of abandonment (M5, S25 and CT50) showed approximately the same runoff production, whereas eroded sediments (ES) and DOC were inversely correlated. Organic carbon in the eroded soil (ES) and dissolved organic carbon (DOC) in runoff water always increased with the period of abandonment, which accounted for consistent nutrient depletion. Nevertheless, the CT50 environment (dominated by *Quercus suber*) showed the best soil properties, whilst soil properties of the S25 environment with dense cover of *Cistus monspeliensis* and *Calicotome espinosa* were not proportional to the amount of vegetation mass, i.e. low organic matter, high bulk density, low water retention capacity. This is probably because these environments are more severely damaged by wildfire occurrence and soil properties are affected too. Sediments yield of P50 environment followed CTS environment, indicating that reforestation without proper management may negatively affect both soil properties and response to the erosive action of rainfall.

## Organic Fraction, Biological Activity and Water Contents of Soil in Relation to Vegetal Cover in Mediterranean Areas

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Interactions between climate characteristics and human activity have been recognised as the main cause of Desertification in Mediterranean areas. Soils are complex resources that reflect equilibrium/disequilibrium between them because they are both the medium supporting the human activities and the natural environments resulting of the interactions between abiotic (lithology, topography, climate) and biotic factors (vegetation, biological activity).
In the context of climate and land use changes, considerable research efforts are been done to find soil desertification indicators. Among these, organic matter content in soils is a main indicator influencing important hydrological properties such as soil aggregation, erodibility, infiltration and erosion, and also a very important indicator of soil fertility and biological activity. Although the importance of these interactions is widely recognised, it is poorly documented for the soils subjected to the abandonment of the agricultural practices in the Valencia region.
In this work we analyse the relationships between the organic matter amount and type, the biological activity and the soil water content of a very common soil in the region under different plant species and vegetal cover as a result of the age of abandonment of agricultural practices.
The soil water contents underneath the different plan species increase with the organic carbon content and the amount of arthropods in the soil as indicator of biological activity. Moreover, the soil water content varied with the type of the dominant organic fraction (humic and fulvic acids, and humine). There was also a relationship between the dominant organic fraction and the type of arthropods in the soil samples.
From the partitioning of organic carbon in humic and fulvic acids, and humine, polymerisation and structural stability indexes were derived. These indexes exhibit good correlation with the T50 obtained from the application of conventional aggregate stability tests such as the CND water-drop test.
By IR spectroscopy functional groups of the main components of leaves, stems and roots of the different species were identified as being transformed in the humic fraction. The role of the different plant species in the dominant organic fractions and stability of the soil aggregates is evidenced.
In the context of desertification in Mediterranean areas, soil quality indicators based in organic matter contents should take into account the type of humus dominating it and the active functional groups implied in the stabilisation of aggregates.

# TOPIC 5:
# FORECASTING TECHNIQUES AND ADVANCES TECHNOLOGIES

## Using the ESAP-95 Software Package as a Tool for Assessing Soil Salinity/Salinization, a pre-Condition for Land Desertification

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Soil salinity/salinization is one of the degradation processes leading to land dessertification. It reduces soil quality, limits the growing of crops, conditions the agricultural productivity, and in severe cases, leads to the abandon of agricultural soils. It is estimated that, in the European Union, soil salinization affects around 1 million of hectares, mainly in the Mediterranean countries, and it is generally accepted that the extent of salt-affected soil is increasing. Soil salinity naturally occurs in the landscape, while soil salinization is, in general, a process linked to the irrigated areas with poor water management. Controlling this problem requires inventorying, mapping and monitoring the natural and induced soil salinity. The objective of this work is to use the ESAP95 software package as a tool for assessing soil salinity/salinization at field scale, applying it to a salt-affected soil (RIB1) from the irrigated district of “Dehesa de Ribaforada” (Navarra, Spain) to analyze, predict and map the soil salinity. This software packet, developed by the United States Department of Agriculture (Salinity Laboratory, Riverside, CA), facilitates the effective use and interpretation of survey conductivity information acquired by the electromagnetic induction sensor EM-38 (Geonics Ltd.). The soil conductivity survey of the RIB1 field through the EM-38 sensor was the first step of the study, collecting data about its apparent soil electrical conductivity (ECa). Then, a reduced number of soil samples were taken for the EM-38 calibration in that plot. The application to both types of data of the three software programs of the ESAP-95 package allowed to (1) analyze, process, and display the acquired conductivity survey information, (2) generate optimal soil sampling plans based on acquired conductivity survey data, (3) convert the survey data into spatial soil salinity information using the soil sample information, and (4) generate field scale salinity inventory statistics, crop yield loss predictions, and spatial salinity maps. This data processing methodology is a breakthrough in the ability to rapidly and accurately assessing soil salinity in agricultural lands. Assessing and controlling soil salinity is one of the necessary actions to prevent/reduce land desertification.

## Assessment of Soil Erosion Risk Using Multivariate Geostatistics

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Soil degradation is referred to as the reduction of the biological or economical productivity of the soils, due to processes including erosion, change of physical or chemical state (acidification, compaction, salinization) and loss of nutrient or organic matter. Although climatic factors often contribute to cause it, soil degradation is generally related to human activities as deforestation, agricultural intensification and urban expansion. This is the case for the Mediterranean regions of Europe, where erosion processes are particularly severe. Assessment and mapping of erosion risk can be a useful tool for mitigating these phenomena. That can be done by individuating specifical indicators and defining an operative methodology for appropriately weighting and combining them. We have developed a new approach based on multivariate geostatistics and GIS that allows taking into consideration in a flexible way a potentially unlimited number of indicators. This method transforms measured data values into a binary value according to specific criteria. The criteria, developed independently for each indicator, are critical values or ranges of values representing the condition in which the single indicators determine a significant degree of risk. These criteria have to be calibrated locally. Each soil indicator is then mapped as the probability that an area is subjected to the risk of erosion. To interpolate these information, we have utilised an approach based on non parametric geostatistics called indicator kriging. We have then applied factor kriging to define two synthetic weighted indexes summarising the effects of several variables on soil erosion.

We present here an example of application to a study area in Sardinia (Italy), which is considered representative of Mediterranean zones at high erosion risk. We selected six variables affecting soil erosion: arable soil depth, organic matter, slope, a texture index, drainage class and land use. We produced maps of both individual soil indicators and synthetic indexes. This procedure allows the identification of both the areas at high erosion risk and the single indicator parameters that cause risk in those zones, thus allowing specific management plans or land use policies to be developed.

## Prediction of Soil Erosion in a small Mediterranean Basin Using a USLE-SIG Application Modified by Rainfall Simulation Tests

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SIG is a selection tool for the study of erosion in small catchment scenarios; meanwhile most of the research is focused in plot observations. The use of USLE equations and their modifications is one of the first developments for small basin using GIS techniques.

The main objective of this work is to test the role of factor C in the final result of the USLE, using two approaches. The first one based on predetermined values of C according to the data of vegetation type. In the second approach, the data of C were modified using experimental results of 29 rainfall simulation test realised in five characteristic types of scrubland.

Case study area is located in the Arroyo de la Vega basin, in Madrid. This basin has been monitorized since 1999. This areas show a Mediterranean pluviseasonal oceanic climate with a average annual precipitation of 458 mm. The main geological materials are: Pontient limestones and Pleistocene crust in the *paramo*, and marls, lime, clay and gypsum of the upper and medium Miocene on the slopes. The representative soil units of this area are: Calcisols, calcaric, rendsic and lithic Leptosos plus calcaric Regosols, and in some occasions Gypsisols. This area is classified by the Autonomous Government of Madrid as significant erosive area.

All the factors of the USLE were recorded and implemented in ARC-GIS 8.2 and the total sediment wash-out calculated. After that, factor C was reclassified using an *ad hoc* function developed for the five main types of vegetation. This functions show the relation between vegetation cover and sediment yield. In general terms the relation of vegetation cover and loss of sediment show a significant statistically relationship. ($r= -0.73$; $p<0.01$). Results show slightly differences between both approaches, in the second one, in which data were reclassified, high erosive classes (>30 t $ha^{-1}$ $yr^{-1}$) areas increases while low erosive classes (< 30 t $ha^{-1}$ $yr^{-1}$) area decreases.

## Desertification Monitoring over the Iberian Peninsula using the Wavelet Transform Technique

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Desertification has increasingly become a threat in the Mediterranean area, and specifically in regions of the Iberian Peninsula, due to both climatic and human factors. To monitor the land degradation and cover changes that desertification involves, vegetation dynamics appears to be a good indicator, through vegetation indices analysis.
In this work, time series of NDVI have been analysed to extract information about both the trend and the variability of the series. The trend is an indicator of the long-term behaviour of soil and vegetation, whilst variability represents the annual cycle of vegetation and, thus, its health state. Estimators of both trend and variability have been obtained by spectrally analysing the NDVI time series applying wavelet transform. This spectral method is advantageous when compared to the most commonly used Fourier transform, because the latter requires stationarity in the analysed series, while wavelet transform is not constrained by this requirement and fits better for the study of an intrinsically non-stationary process such as desertification. The NDVI dataset used in this work consist of a 14-year long time series of 10-day composite images extracted from the Mediterranean Extended Daily One-Km AVHRR Data Set (MEDOKADS). Wavelet transform was applied over the individual pixels of the series of images, decomposing the time series in low and high frequency time functions to describe the trend and the variability of the original time series at different time scales. After the wavelet transform has been performed, key descriptive statistics are applied to reduce the computed information and form estimative trend and variability images. This technique has been successfully used over a wide range of surface types, ranging from dense and dark vegetation to desert regions, showing thus its robutness.

## Influence of Inorganic Fertilizers and Organic Amendments on Potential Phosphohydrolytic in a Soil

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To conserve the productivity of agrosystems and reverse the degradation in soil for the long-term is important the control and maintenance of the organic matter (Clapp *et al*., 1986; Tate, 1987). Because of the limitation of the used traditional organic fertilizer (manures, peat,... etc.) have been looked for in the last years rich urban waste in organic matter and source of nutrients for the plants (Gallant-Lara and Walnuts, 1987). The incorporation of these organic materials to the soil improves its microbial activity and the processes of mineralization of the biomass contributing C, N, P and S.

Soil enzymes play an essential role in catalysing reactions necessary for organic matter decomposition, frequently these enzymes are used as indexes of quality of the microbial activity and of the fertility of the soil (Kumar Jha *et al*., 1992; Dick, 1994).

In this study the effect of the application of inorganic fertilizers (different proportions NPK) and organic amendments (sewage sludge and municipal solid waste to different proportions) has been evaluated about the biochemical properties of a soil Calcic Cambisol (FAO-UNESCO, 1998).

The experience, along 6 weeks, was carried out in plants plots with 2600 g of soil (<2mm) in incubation at 37ºC, with 9 treatments (combining the proportions of organic and inorganic fertilizers) and a control plot. The experience was carried out had quintupled for its statistical study. Every week was evaluated the content in assimilable phosphorus and the phosphatase activity. The obtained results show that when Municipal Solid Waste is added to the soil the APh decreases along the time, recovering the control's levels in the 6ª week. When the treatment is made with Municipal Sewage Sludge, the APh overcomes those of the control in the 2ª week. The application of inorganic fertilizers doesn't suppose any increment of the enzymatic activity. The combined treatment presents the same behaviour that with the addition of organic amendments.

*Keywords*: degradation soil, sewage sludge, municipal solid waste, phosphatase activity, assimilable phosphorus.

## Does Anthropogenic Activities or Nature Dominate the Shaping of the Landscape in the Oregon Pilot Study Area for 1990-1999?

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Climatic variation and human activities are major factors resulting in land degradation in arid and semi-arid lands. In the Mediterranean region and over history, climatic drying was coincidental with developing agricultural technology and the rapid increase of the population and their dependence on the grain field, timber, and animal products. As a result of human population demand, it is evident that depletion of natural resources, such as water (surface or ground) and soil (e.g. soil erosion), and reduction of farm productivity lead many farmers to move to alternative lands or to urban areas. This has a major impact on socio economics by decreasing per-capita food production and enhancing poverty that affect the political stability of the region.
Desertification can be evaluated using environmental degradation, however, it is important to separate degradation that occurred naturally (fire, flood, drought, etc.) or as a result of anthropogenic human activities (urbanization, livestock grazing, etc). Here we report the use of advanced technology to map changes in vegetation cover that enable managers to geographically locate major changes in loss or gain of vegetation cover. Vegetation greenness was assessed over a ten-year period (1990 – 1999) using 1 km Normalized Difference Vegetation Index (NDVI) data derived from Advanced Very High Resolution Radiometer (AVHRR) bi-weekly composites. A regression model of NDVI with time was developed to identify long-term trends in greenness for each pixel in a study area State of Oregon, USA. Greenness is highly correlated with precipitation, so general precipitation trends were also calculated for each station in the study area. Localized analysis was also performed around precipitation stations, comparing NDVI and rainfall trends in a 3 km x 3 km neighborhood centered on each station. A decreasing trend in vegetation greenness was an indicator of some type of stress, either natural (drought, fire) or anthropogenic (excessive grazing, urban growth) in origin. The method presented here allows mapping greenness trends over large areas quickly and inexpensively, providing land managers a useful tool in locating areas in most in need of remediation or protection efforts.
Results were mapped using ArcView for visualization and assessments. Three patches of decreasing greenness were identified and analyzed, along with two patches of increasing greenness. Analysis was performed using ancillary data and people with extensive knowledge of the area. Degradation causes were identified as urban growth and fire, increased greenness was attributed to recovery in timber harvest areas.

## Monitoring Soils to Detect Temporal Changes in Selected Properties and to Prevent Desertification Process in a Irrigation Area from Portugal

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Applied irrigation water can have an adverse effect on the chemical and physical properties of the soil. Therefore, the irrigated soils should be monitored, periodically, to detect changes in their properties. In order to prevent desertification process the soils from an irrigated area, border between Spain and Portugal, were monitored and 1428 georeferenced topsoil samples were analysed. The results verify a generalized acidification of the irrigated soils, comparatively to the soils maintained as dry land. Simultaneously, an increment in the electrical conductivity values and exchange sodium percentage were verified. With the Vertisols exception, a significant decrease in organic matter contents for the irrigated soils was also verified. All these variations are significantly accentuated as time goes by, at least for a period up to 30 years. The information was implemented in a Geographical Information System which allows the detection of the higher impact areas, due to irrigation, and the delimitation of particularly vulnerable zones, where special attentions would be recommended for soil conservation.

## Vegetation Recovery Using Multitemporal Landsat TM Images. An Assessment to Map Erosion Sensitive Areas after Forest Fires

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The burning of the ground-covering vegetation generally leads to an increase in the erosion processes. Nevertheless, the rapid rates of vegetative regrowth following fire reduce runoff and sediments yield rates. Regeneration strategy and vegetal cover of species prior to fire are important factors controlling the space discontinuities of the processes of vegetation covering and geomorphology reactivation post-fire. The aim of this paper consists of mapping erosion sensitive areas by means of monitoring the recovery process using satellite imagery (*Normalized Differences Vegetation Index* -NDVI-) and fieldwork data.
Study are is located in Spanish Pre-Pyrenees (Huesca province). This area is specially prone to forest fire and behaving like natural barrier to the morpho-climatic processes of semi-arid areas. Therefore, monitoring postfire regeneration is an important aspect for designing revegetation programs to reduce land degradation and erosion processes in Spain.
The methodology related to the use of remote sensing images has been developed in a framework of changes detection techniques. This implies a robust radiometric and geometric consistence in the images used. Six summer Landsat TM images were selected considering technical and methodological criteria. A second-order polynomial equation and a nearest-neighbour interpolation method were used for the geometric correction, and conversion to spectral reflectance has been applied by normalizing the topographic and atmospheric effects. Subsequently, the burnt area perimeter was delimited, and for determining the types of affected communities a cartography obtained from digital classification was performed. The NDVI of the different images were generated and several linear regressions were applied to model the regeneration process and to detect zones where the regeneration is smaller by using residual values. Such parameters were tested on several sites by fieldwork and high-resolution aerial photography. Finally, an analysis of variance (ANOVA) has been applied and significant differences have been found among herbaceous communities from artificial forestations areas and the rest of communities (scrublands and woodlands).

## How Could Indicators Contribute to Approach Desertification as a Security Issue? A Framework Proposal for the Mediterranean Region

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Despite the seriousness of the environmental and socio-economic impacts of desertification, few efforts have been made to devise diagnostic techniques and criteria for appraising the status and trends of desertification. Most desertification studies have faced the issue under a global and descriptive perspective. At regional and local levels, only studies focussing on individual desertification processes by partial pressures have been carried out. Further research at regional and local scales to reach an integrated and holistic view of the desertification processes and their consequences on ecosystems is, therefore, highly needed. The capabilities of new information techniques and methods (e.g. remote sensing, indicator systems), that facilitate the assessment and monitoring of desertification at regional and local levels, should be explored.
The Committee of Science and Technology (CST) of the United Nations Convention to Combat Desertification (UNCCD) point out the subject of indicators as an important issue in the fulfilment of objectives and aims of the Convention. The CST identifies three kinds of indicators: (i) indicators to assess desertification, (ii) indicators to assess the implementation of the UNCCD, and (iii) indicators to assess the impact of the UNCCD. This paper is focussed on the first kind of indicators including a conceptual approach to both biophysical and socio-economic aspects for the Mediterranean Region. It is highlighted that the different socio-economic and geographical characteristics of the desertification affected areas prevents the use of a universal minimum set of indicators. It is proposed a casual and hierarchical-spatial structure of environmental indicators that covers the heterogeneity of the different areas affected by desertification maintaining at the same time a reduced number of indicators. It is also proposed a set of human driving forces as a preliminary step towards identify and validate socio-economic desertification indicators. This framework proposal aims at helping decision-makers undertake appropriate action in combating desertification as a security issue.

## Use of remote sensing and GIS techniques to determine susceptibility of soil to runoff erosion

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Soil erosion processes are one of the main effects of forest fires since these destroy the vegetal cover protecting the surface and top layers of soil. The first rainfalls after fire fall on an unprotected bare soil and can result in runoff erosion serious enough to impede regeneration of the vegetation. This type of erosion, which leads to desertification, is certainly the most intense and damaging in Spain.
Once fire is controlled, a plan should be devised to regenerate the vegetal cover and thus avoid significant soil losses that may produce irreversible or difficult recovery situations. When planning, it is necessary to identify those areas that are more likely to undergo erosion or that experience greater regeneration difficulty, giving them preference.
This paper proposes a methodology based on Remote Sensing and GIS techniques for assessing soil susceptibility to runoff erosion in Mediterranean semiarid forestlands after wildland fires. Basically it deals with biological and topographic features. To validate the method, it has been tested after a large forest fire in South-Eastern Spain.
This methodology is applicable to any surface of burnt forest and allows us to obtain, in a rapid and cost-effective way, a map of soil susceptibility to hydric erosion. The results have proved that the technique is a useful tool for environmental management, providing criteria to prioritize actions in order to avoid, or at least minimize, soil losses due to rainfall and runoff erosion.

## Current Natural and Anthropogenic Climate Change and Aridization in the East Margin of the Mediterranean Region

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The study of lakes and lacustrine deposits makes it possible to trace climatic and related environmental changes in the past and forecast their development in the future. In the Caucasian part of the Black Sea region, the appearance of new lakes in the highlands due to the retreat of mountain glaciers has been observed in the periods of climate warming (the end of the 19th century–mid-1930s, mid-1960s–present). Until the 1990s, the level of lakes in low coastal and piedmont areas remained more or less stable. In the last decade, a decrease in the level of lakes of different origins (karst, seismic, naturally dammed rivers), their overgrowing with meadow vegetation, and their disappearance have been noted in these areas, especially in the most densely populated coastal zone. This tendency manifests itself against the background of an increase in the annual precipitation.

The reasons for this phenomenon are connected with the (a) lowering of the base of erosion due to the uptake of water for industrial and agricultural uses and (b) high input of biophilous elements and sediments into the lakes from the ploughed watersheds. Our studies (2002 and 2003) showed that 4 natural water reservoirs (rivers and mires) disappeared in the area of Adler; 5, in the area of Khosta; 2, in the area of Matsesta; and 2, in the area of Dagomys. This decrease in the area of lakes and wetlands in coastal regions (including low mountains) can be considered the first sign of the human-induced aridization.

Environmental implications of this process may be very significant. An increase in the degree of climatic contrast (first of all, temperature contrast) between the high-mountain and coastal regions should intensify convective movements of heated air masses from the coastal area into the nival zone, increase precipitation in high mountains, and activate destructive exogenous geological processes in the high mountains and all lower-lying landscapes. The Karmadon Glacier tragedy of 2002 illustrates the disastrous character of these processes. Thus, the strengthening of climate contrast connected with human-induced aridization will increase sediment discharge into the Black Sea. Further collaborative multiple studies into this problem are required. In particular, it would be interesting to analyze the stratigraphy of lake sediments in different altitudinal zones, as similar processes could take place in the past. These data are necessary for developing the strategy of sustainable land management in vulnerable coastal and mountain ecosystems.

The knowledge of the history of local environment and climate as reconstructed from the columns of lake sediments and of the dynamics of contemporary water bodies is necessary for revealing the factors of modern desertification and control this process in the future. Cooperative interaction of administrative, economic and scientific structures could give a chance to preserve natural water reservoirs and stabilize seaside landscapes.

## Development of a Spatio-Temporal GIS to Model Land Use Changes in the Forest of Dadia in Northeastern Greece

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The land use changes of the Dadia forest are examined using GIS and remote sensing in order to find a model that describes best these changes. The land use changes may contribute to severe environmental problems such as in changes in biodiversity, especially in the case of wild birds which are given hospitality in the forest.
The objective of this paper is to model the aforestation between 1945, 1973 and 2001, which is due mainly to biophysical factors. The altitude, the slope, the aspect and the geology are the biophysical factors we studied.
Air-photos of the forest for the years 1945 and 1973 as well as a satellite Iconos image for June 2001 and the geologic map of the area have been the source data for this study.
Raster maps were produced. We call these maps suitability maps because at each point store a number from 1 to 100 that express its suitability for change.
The maps of suitability for aforestation are made using linear and logistic regression, fuzzy logic theory techniques. The suitability maps which predict the changes (aforestation or deforestation) were validated with real data using the Relative Operating Characteristic technique (ROC).

# SMOS REFLEX 2003: Preliminary Results of Soil Moisture Dependence of the L-Band Brightness Temperature of Vineyards Measured with the LAURA Radiometer

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The SMOS REference pixel L-band EXperiment (SMOS REFLEX '03) field experiment took place in June-July 2003 at the VALENCIA ANCHOR STATION site, in Valencia, Spain. It is the first of a set of field experiments devoted to the characterization of a potential large area with very few land uses that could be suitable as a reference pixel for SMOS ground calibration. Three research institutions were involved in this experiment: the *Centro de Investigaciones sobre Desertificación* (CIDE, Valencia), the *Climatology from Satellites Group from the Department of Thermodynamics of the University of Valencia* (UVEG, Valencia), and the *Department of Signal Theory and Communications from the Universitat Politècnica de Catalunya* (UPC, Barcelona)

The *Microwave Radiometry Group* of the UPC was in charge of the brightness temperature measurements of a vineyard field under different soil moisture conditions during two complete cycles from water saturation to dryness. The main goal was the study of the dependence of the brightness temperature with soil moisture, as well as other parameters such as soil roughness, vegetation opacity and albedo. The instrument used was the L-band AUtomatic Radiometer (LAURA). The second goal of this project was the retrieval of soil moisture content from multi-angular radiometric measurements, as in the ESA SMOS (Soil Moisture and Ocean Salinity) mission. Simultaneously, the UVEG-CIDE group took ground measurements of soil moisture, roughness, slope, soil temperature, vegetation morphology, and leaf area index (LAI), from the same vineyard field to help the improvement of the numerical electromagnetic models.

The soil moisture sampling design involved around four hundred point measurements (sampling density of 1 point per squared meter) with capacitance sensors on a daily basis. The soil specific calibration was carried out prior to the field experiment. The design was stratified by soil pattern in order to catch soil moisture variability sources. To characterize the site a full soil profile analysis and a soil surface characteristics analysis were made.

Soil temperature was measured at 1, 5, 10, 15, 20 and 40 cm depth by means of six thermistors in continuous operation. The vegetation sampling involved basic measurements of the vineyard architecture for each vegetation compartment (stem, branches, leaves), and LAI measurements. Two approaches were followed: diagonal transects covering two rows (with parallel and normal to row viewing), and transects along the vegetation lane. A full plant was collected for a coarse estimation of the water content per compartment. There is a strong interest in studying the contribution of vegetation to surface emission at L-band for canopies where little studies have been conducted, such as dense canopies and covers without a strong orientation direction, such as vineyards.

This paper describes the SMOS REFLEX 03 field experiment and will present the preliminary results of the data processing.

## Gis Methodology Applied to Chemical Degradation Monitoring in Agricultural Soils

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The alluvial soils of the Segura basin in the province of Murcia (SE Spain), where rainfall may not exceed 300 mm a year are prone to desertification (Le Houérou, 1976), have long been dedicated to growing a variety of crops. During recent years, however, has suffered a number of impacts from various sectors, including urban expansion, the intensification of agricultural practices, the use of poor quality irrigation water (especially during periods of drought) with its associated problems of alkalinisation and salinisation (Pérez-Sirvent et al., 2003), inadequate amendment of the soil by organic materials, continuous phytosanitary treatment and even increased traffic with the corresponding increase in metallic contaminants in the atmosphere.
To monitoring the evolution of chemical degradation in these agricultural soils a six-year long study has been carried out. In an attempt, therefore, samples were taken from the surface soil (0-25 cm) in eighteen sampling points at three times: January 1993, January 1996 and January 1999. In this samples were determined: pH, OM content, calcium carbonate content, EC, SAR, clay, chlorides, sulphates, available phosphorus and nitrates, lead and cadmium total content and lead and cadmium bioavailable (extractable in DTPA solution), and the residues of two organochloride compounds (Endosulfan sulfate and Dieldrin).
Geographical Information System (GIS) methodology can be used to compile, store, and retrieve spatially derived information, producing visual and numerical outputs that can be applied to land management decisions. Desertification most representative parameters for this soils were selected and represented using GIS, and the most affected areas by degradation being identified. Evolution maps developed in this study show zones in which these processes are more pronunced and need planning preventive actions.

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## Multitemporal Remote Sensing of Land Surface Temperatures over the Iberian Mediterranean Fringe

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Citizens, tourists, local farmers and Earth scientists perceive the desertification process of Mediterranean ecosystems. The process is rather complex and multifactorial. Besides, the Mediterranean basin suffers an intense seismic activity, which constitutes a highly impacting natural hazard for the peoples settled around it. Seismology, however, not only rises up subjects related to prediction or civil protection; crust adjustments conform *another* element to consider in the complexity of desertification processes. Each seismic event generates a thermal release that contributes to local desertification. Some consequences experienced of such thermal releases are the next ones: a gradual warming up of the land surface, lower rates of biological activity developed by the vegetation cover as a result of the temperature increase, *earthquake dewatering* which results from liquefaction and it is associated with water and soil emissions.
Space techniques for seismic applications have been focussed in the past to measure crust displacements or deformations produced between different parts of geological active structures using SAR interferometry and accurate GPS measurements. This methodological approach fits better the post-event evaluation rather than the prevention. Our research presents the method to record the **thermal flux releases** that occur during crust displacements, which in turn develop a *desertifying reaction chain* in the upper-laying ecosystems. The study is carried out through a 47 month series of NOAA-AVHRR observations, from which land surface temperatures (LST) were derived. The observations period runs from 1996 to 2001, which allowed us to verify the actual warming up of some points seismically active along the Spanish Mediterranean coast. This research was funded by the EU which allowed the research team to verify the results across the Mediterranean basin in Greece and Turkey