# Multi - temporal assessment and monitoring of desertification using the Environmental Geographic Information System of Andalusia


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JUNTA DE ANDALUCIA

DESERT2

EUROPEAN UNION
European Regional Development Fund

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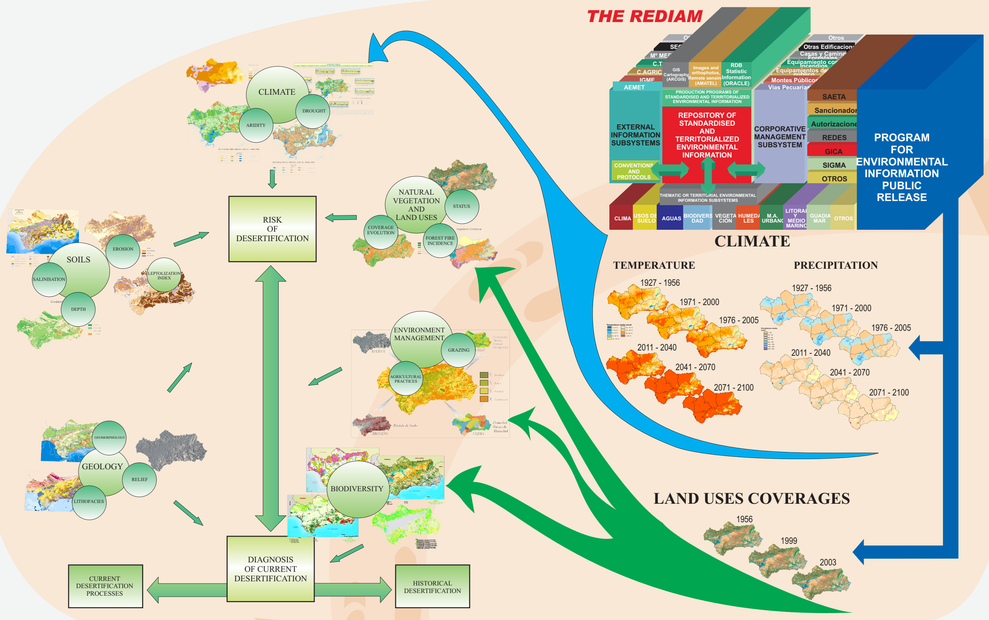
**Desertification is not a new phenomenon. Given its standing incidence, desertification can be defined as historical which is considered difficult to reverse and currently makes up a landscape of high ecological value.**

Desertification, as a process of degradation caused by the confluence of arid or semiarid climatic conditions along with human aggressive and unsustainable actions in the natural and productive environment (and taking into account the current context of climate change), is a dynamic environmental phenomenon which seems appropriate to track, both its recent history and the changes that the new climate scenarios can suggest, in order to develop strategies to mitigate or to value enhancement, in addition to addressing a growing awareness of the challenges that lie ahead.

**Desertification represents a set of processes that lead to land degradation in arid, semiarid and dry sub-humid areas, as result of the interaction of climatic variations and adverse human activities (United Nations Convention to Combat Desertification, 1994).**

The availability of historical information in a geographic information system concerning land use coverages and climate data, along with other environmental information (topography, soils, geology, environmental management ...), as well as climatologic information of the possible future scenarios of change for decennial periods up to 2100 within the Environmental Information Network of Andalusia (REDIAM) has allowed, in the framework of European projects DesertNet I and DesertNet II, the development of models for the diagnosis of the affected areas by historical processes of desertification and the areas of current and future impact. At the same time this common methodology has been applied to the European context to delimiting the susceptible areas to degradation. These models were applied to the entire territory of Andalusia obtaining a picture of the temporal and spatial occurrence of this phenomenon.

**Desertification is also evident in areas where the processes are active at present. The current desertification of these areas have a level of deterioration that has not yet reached irreversible levels and it is possible to mitigate the impact of this problem through the adoption of remedial measures.**







The diverse and varied information necessary to make this process of evaluation comes from the Environmental Information Network of Andalusia, which produces, standardizes and distributes information on the environment in Andalusia.

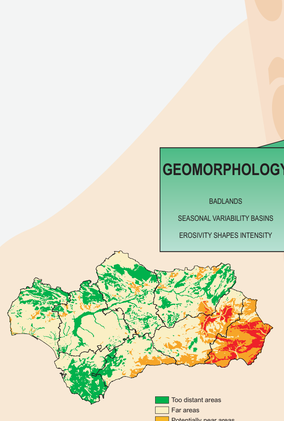
Some of the information, considered as the most dynamic, is the result of ongoing programs to generate information which have resulted in a multi-temporal study of desertification. Within this category of information is the climatic, land uses, vegetation, biodiversity and groundwater data. The first and the second have been made within the context of the Enviromental Geographic Information System of Andalusia; the third has been gathered from various publications (IGME 1988, 1998); the other information, which is less dynamic (geomorphology, soil, lithology, relief, intensive erosivity forms, land use capacity....), has remained constant in the evaluation process.

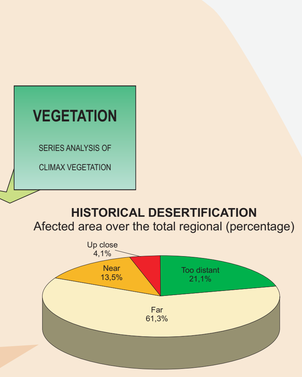
For the analysis of climatic and environmental conditions in the twentieth century were used data of precipitation and maximum and minimum daily temperatures from weather stations located along the region. Most stations are part of the Secondary Meteorological Stations Network of the Meteorology State Agency, although data from automatic weather stations of the same Agency were also used to calculate the erosivity of rain.

The calculation of the scenarios of precipitation and temperature in the twenty-first century developed for the Regional Ministry of Environment have been obtained by downscaling techniques from three General Circulation Models: the German ECHAM4/OPYC3, the Canadian CGCM2, and the HadAM3 of Great Britain. All three models have been applied over two scenarios of future emissions: the A2, characterized by a continuous growing, and B2, which emphasize environmental protection and trends toward social equality.

The evolution of land uses in Andalusia in the years 1956, 1999 and 2003 has been defined on a common base map and a single information coverage through a process of changes interpretation. It has been interpreted with similar criteria (Moreira et al., 2007) which makes any analysis consistent and not influenced by geometry or divergent interpretations.

All graphic information, both produced with the vector format as the one obtained in raster format has been adjusted and / or converted to a grid of 80 meters with a single origin and covering the entire region, in order to perform all the processes of calculation. The tools used in information processing have been ArcInfo and ArcGIS 9.2 for the treatment and management of both raster and vector information, Amatel for raster information and Arcgis 9.2 for the analysis and graphic representation of results.

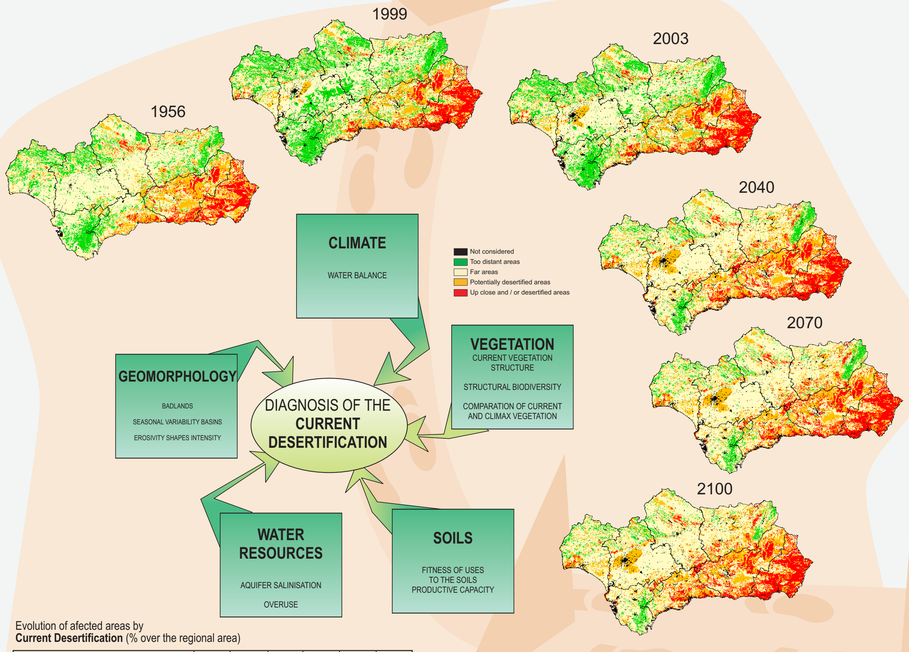



Areas, where since ancient times processes have led to desertification causing a deterioration on the territory and over its productive capacity, have to obtain agricultural production using elements of high technology and inputs of high value, in addition to perform actions of strong impact on the environment.

These are lands where desertification is a natural process to which human activity has been adapted from historical time, practically since the beginning of civilization. This combination of factors has created a desert landscape that is in itself an area of high ecological and landscape value where more than its recovery, we should consider putting in value as a unique environmental resource.

From information about climate, geomorphology, soils and vegetation climax and through their analysis and combination has been made a complex diagnosis that determines the areas where desertification can be seen as a legacy.

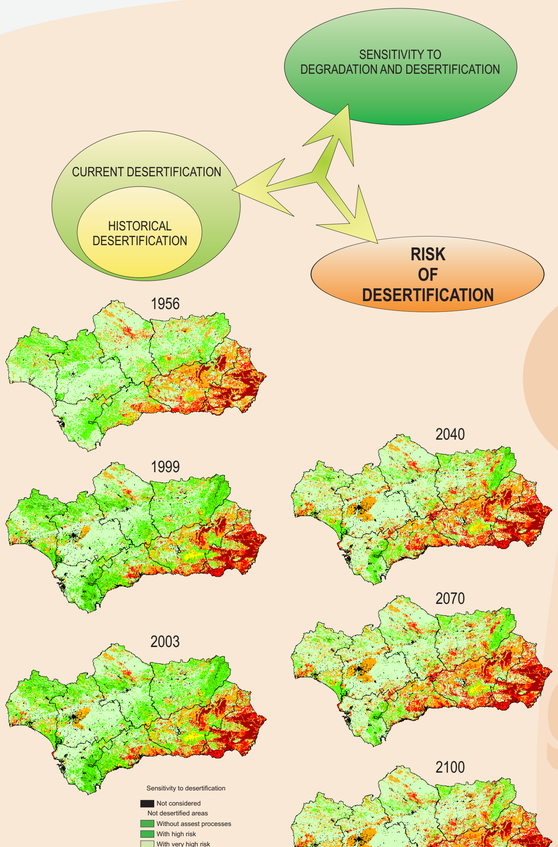



Evolution of afected areas by **Current Desertification** (% over the regional area)

| SCENARIO | 1956 | 1999 | 2003 | 2040 | 2070 | 2100 |
|---|---|---|---|---|---|---|
| Not considered | 0,95 | 2,84 | 3,09 | 3,09 | 3,09 | 3,09 |
| Too distant areas | 15,15 | 23,18 | 18,82 | 6,66 | 6,18 | 4,96 |
| Far areas | 57,89 | 50,17 | 52,48 | 56,19 | 56,46 | 57,28 |
| Potentially desertified areas | 17,40 | 14,88 | 16,04 | 21,17 | 21,25 | 21,35 |
| Up close and / or desertified areas | 8,61 | 8,93 | 9,57 | 12,89 | 13,02 | 13,32 |

In relation with the desertification phenomenon described as a naturalized or inherited, resulting from the evaluation of historical cycles or processes from long time, there are processes that operate on both, desert areas and others who have recently suffered or are suffering damage that can lead to desertification.

The combination of classified information on climate, groundwater, suitability of uses and productive capacity of soils, land uses and biodiversity and geomorphology determines the areas deserted or near to desertification, where processes are currently active. These areas have a traditional and marginal agricultural production or have been abandoned, accentuating degradation and surviving only modern technology and high added value farms, which are able to make the investments required for their production. Once current desertification have been represented, it has been added all those areas diagnosed with inherited desertification obtaining all the desertified areas at present, both because of historical or naturalized reasons as those that are the result of recent developments.




The combination of the three previous diagnoses in a single coverage will enable us to define the status of the lands of Andalusia in terms of desertification together with the identification of areas where the processes that cause are more active, determining the risk of desertification. This combination of information can be used as a basis for policy actions and highlighting areas naturally affected by recent actions and areas not affected but with a strong incidence of processes that lead to long-term degradation processes of the environment, which will lead to a situation close to desertification.

Except in particularly aggressive events, the results show that land degradation happens in a gradual and incremental manner through extended periods of time. Therefore, the general perception of the problem is more than generational, making it difficult to raise awareness and get an overview of it.

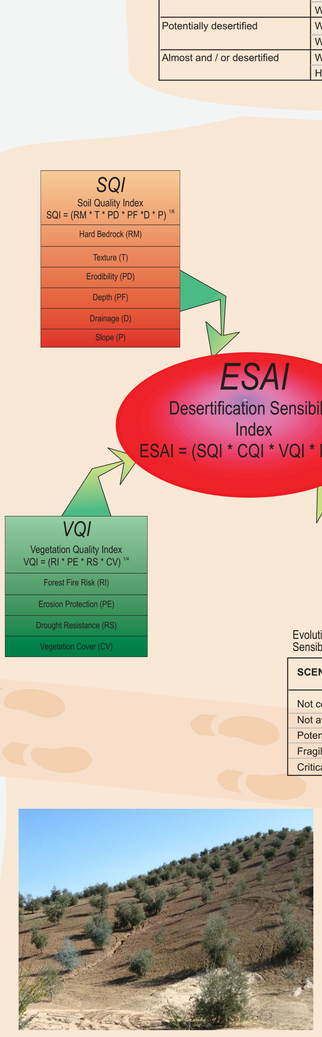
The growth of potentially desertified areas is as important as the growth of real desertified areas. This is an indicator of areas where we must concentrate corrective actions, such as Almeria and Granada, where the growth of desertified areas occurs at the expense of potentially desertified areas.

It is noteworthy to point out some parallels found between the evolution of desertification and the evolution of desert areas: from an especially desertified area, it will expand the bordering areas who suffer recurrent cycles of affectation as can be seen in the series of maps and scenarios projections of the risk of desertification.

The proposed strategy, monitoring and projection into the future of desertification processes at the core of the Environmental Information Network of Andalusia through GIS tools shown, not just as an effective diagnostic tool, but as the guarantee for the monitoring and delimitation of affected areas and it will be used to focus efforts on prevention and mitigation, covering various strategic plans that govern the actions of the Regional Ministry of the Environment, especially in the Andalusian Plan for the Control of Desertification, currently in draft.

Evolution of the desertification risk (% over the regional area)

| SCENARIO | | 1956 | 1999 | 2003 | 2040 | 2070 | 2100 |
|---|---|---|---|---|---|---|---|
| Not considered | Not considered | 1,08 | 3,20 | 3,46 | 3,46 | 3,46 | 3,46 |
| Not desertified | Without active processes | 0,32 | 3,34 | 3,28 | 0,72 | 0,49 | 0,07 |
| | With high risk | 20,55 | 28,26 | 27,92 | 12,12 | 11,66 | 7,44 |
| | With very high risk | 52,11 | 41,60 | 39,93 | 49,92 | 50,41 | 54,64 |
| Potentially desertified | With high risk | 1,55 | 3,07 | 3,55 | 1,80 | 1,79 | 1,05 |
| | With very high risk | 15,82 | 11,68 | 12,36 | 19,23 | 19,32 | 20,16 |
| Almost and / or desertified | With very active processes | 4,44 | 4,72 | 5,34 | 8,60 | 8,73 | 9,03 |
| | Historical | 4,14 | 4,14 | 4,14 | 4,14 | 4,14 | 4,14 |




Evolution of the Degradation-Desertification Sensibility (% over the regional area)

| SCENARIO | 1956 | 1999 | 2003 | 2040 | 2070 | 2100 |
|---|---|---|---|---|---|---|
| Not considered | 1,09 | 3,22 | 3,49 | 3,49 | 3,49 | 3,49 |
| Not afected | 0,00 | 0,79 | 0,68 | 0,15 | 0,09 | 0,01 |
| Potential | 0,32 | 3,02 | 2,76 | 0,59 | 0,42 | 0,07 |
| Fragile | 22,33 | 32,48 | 31,89 | 14,18 | 13,71 | 8,72 |
| Critical | 76,26 | 60,49 | 61,18 | 81,59 | 82,29 | 87,71 |



To characterize the sensitivity to degradation-desertification, model MEDALUS (Kosmas et al., 1999) has been used to identify vulnerable or susceptible areas to desertification through the application of biophysical and socio-economic indicators. This model has been chosen by the various partners involved in European projects DesertNet 1 and DesertNet 2 as the model of diagnosis in order to have a common vision of these problems in different countries of the northern Mediterranean arc.

Basically the model is based on the implementation of four quality indices directly related to desertification: soil, climate, vegetation and land management. Within each factor is an analysis of key parameters or indicators that explain their sensitivity to degradation. The processesses of information crossing are carried out through geometric means and classification.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