Desertification and land degradation investigations in the Mediterranean basin based on hydrological and remote sensing data interpretation.

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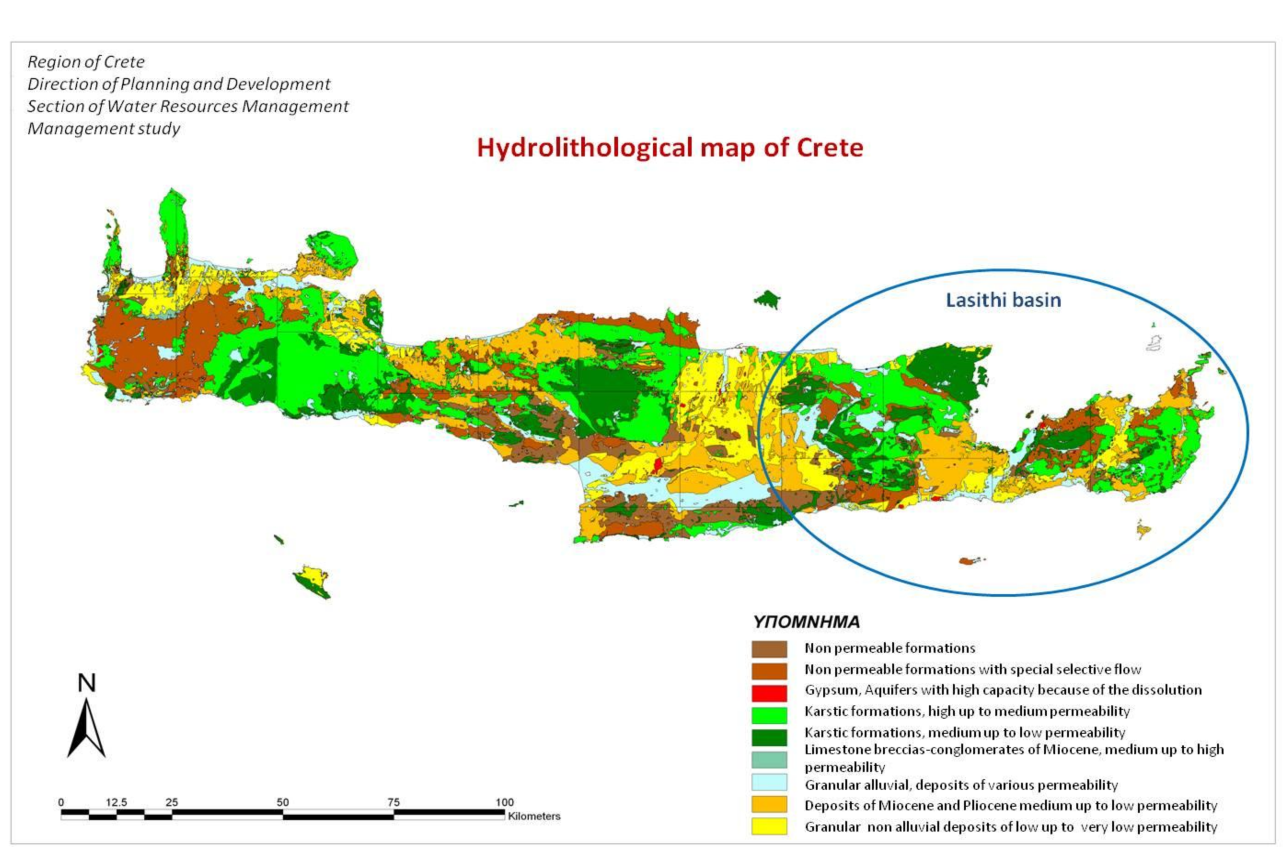
Abstract

Desertification in the island of Crete takes place as a consequence of: (i) climate conditions and (ii) anthropogenic activities causing intrusion of seawater into the mainland aquifers.

Remote Sensing techniques can be a useful tool in various fields of environmental research, while satellite image processing can be used for assessment and monitoring of environmental analysis, land cover/use changes, landscape mapping and soil analysis. In the case of Eastern Crete, remote sensing digital image analysis can be applied to monitor desertification process, by comparing Landsat images of different dates in order to detect changes in land cover and land use over time in the research area.

This research involves the interpretation of hydrological, hydrogeological and meteorological data in combination with remote sensing techniques in order to determine the extent of desertification in a critical area of Crete Island, Greece. The study area is envisaged to serve the needs of a reference site representing typical Mediterranean conditions with a high potential of desertification -due to climate conditions- and land degradation -as a consequence of soil salinization.

1. Introduction



Lasithi terrain is characterized by the existence of mountain Dikti (2.148 m), Thripti (1.476 m) and Sitia mountains in the east (819 m).

The carbonate formations of the study area support important karst systems, which are important in terms of the karst system Dikti which extends in the prefecture of Heraklion, Sitia karst system - Paleokastro and karst system of Ornos - Thrypis. In the area of Lasithi, karstic aquifers are developed, three are the main karstic systems (Dikti, Siteia-Palaiokastro, Ornos-Thrupis).

The karstic aquifer system of Paleokastro and Sitia, is of high capacity and it covers the irrigational and potable water needs. The karstic aquifer of Ierapetra area are low in capacity. The water resources of this area are fully exploited. The aquifers in the inland of Sitia are of good quality instead of the coastline aquifers which are brackish.

In the study area, there is touristic development and the water needs , especially in the summer period are significantly increased, the overexploitation of the aquifers for covering these needs, additional to the irrigation needs.

2. Remote Sensing Methods

Several Landsat images (from 1984 to 2011) of the research area, were downloaded from the USGS website and were processed , using the remote sensing/GIS programs ER MAPPER (v. 7.1) and TNT mips. The purpose of the image processing is to investigate the desertification hazard of the Eastern Crete area, based on the changes on vegetation, during a period of 26 years. The main processes that were used in this poster presentation, are :

- NDVI (normalized difference vegetation index),
- 5,4,1(RGB)color composite and
- tasseled cap transformation

in order to determine whether there has been a significant decrease of vegetation through the years that would indicate that the research area is in danger for desertification in the future.

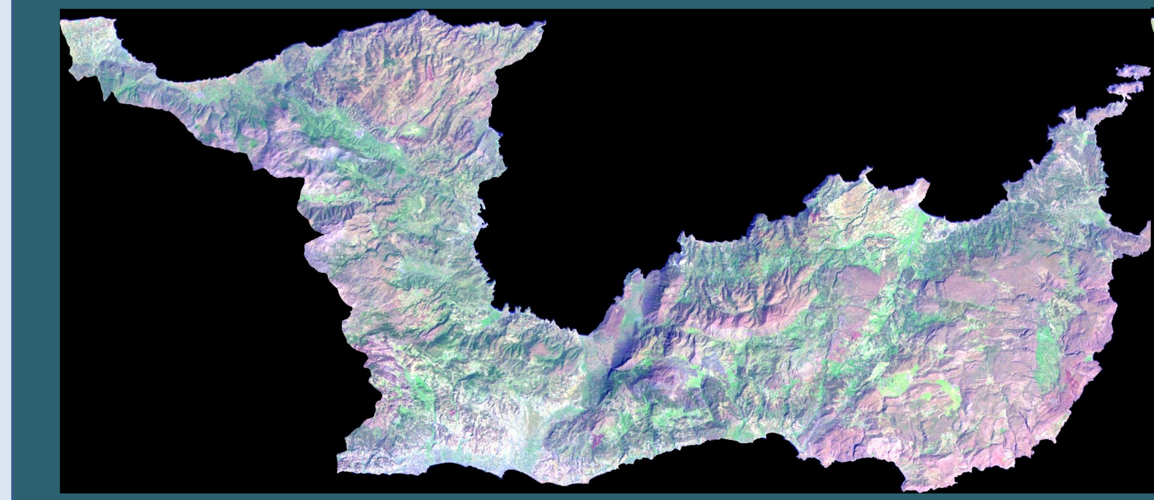


Image 1. 541 RGB 1984

Image 2. 541 RGB 2005

The Normalized Difference Vegetation Index (NDVI) is an indicator, used to analyze remote sensing measurements and determine whether the target being observed contains live green vegetation or not.

The NDVI is calculated from these individual measurements as follows:

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

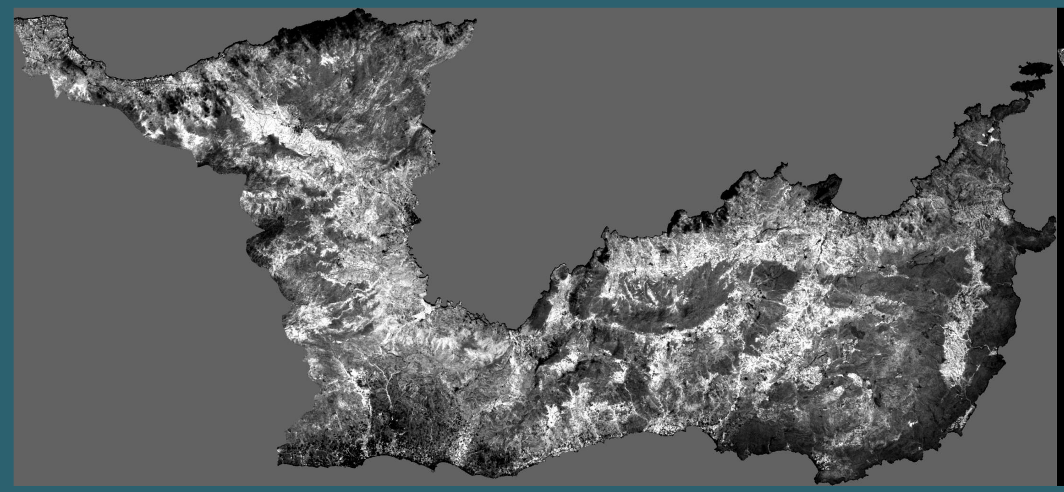
where VIS and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions, respectively.

The Tasseled Cap Transformation in remote sensing is the conversion of the readings in a set of channels into composite values; i.e., the weighted sums of separate channel readings. One of these weighted sums measures roughly the brightness of each pixel in the scene. The other composite values are linear combinations of the values of the separate channels, but some of the weights are negative and others positive. One of these other composite values represents the degree of greenness of the pixels and another might represent the degree of yellowness of vegetation or perhaps the wetness of the soil. Usually there are just three composite variables (Watkins, Thayer 2006)

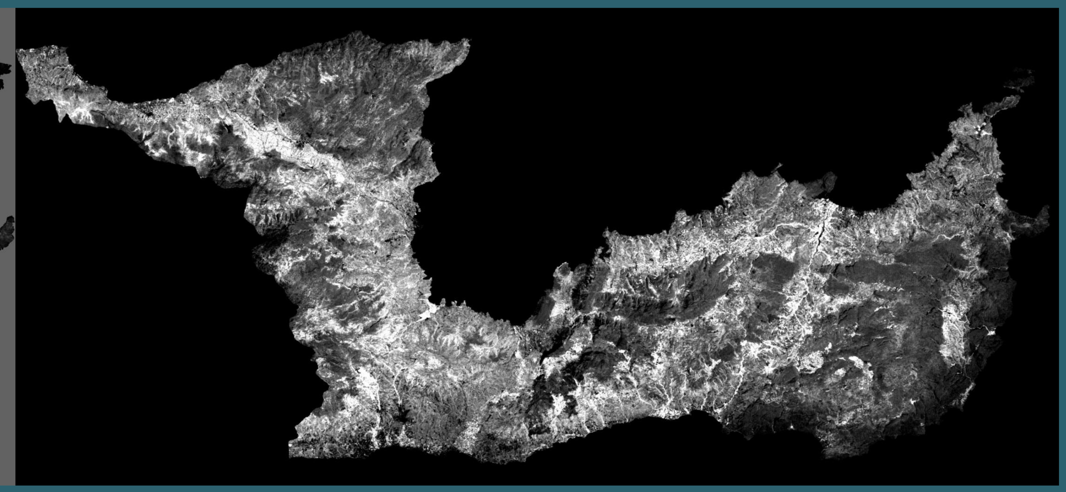
In order to detect changes in vegetation, the images compared, should be taken in the same season and even better in the same month of each year.

NDVI indicator and Tasseled Cap transformation were applied to the 26-9-1985 Landsat 5 and the 11-9-2000 Landsat 7 images and they indicated that there has been a significant decrease in vegetation measurements in the most recent image , as shown on the table below :

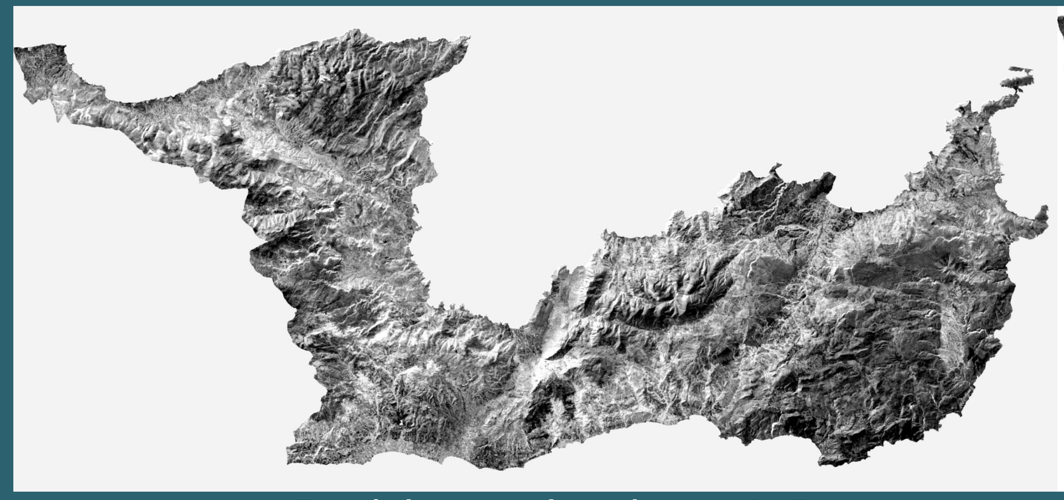
			Tacelled Cap					
	NDVI		Greeness		wetness		brightness	
Date	mean	median	mean	median	mean	median	mean	median
26/9/1985	12,237	11	3,91	2	0,178	0	145,217	146
11/9/2000	3,6907	0	0	0	0,029	0	138,19	136
Difference	0,03	0						



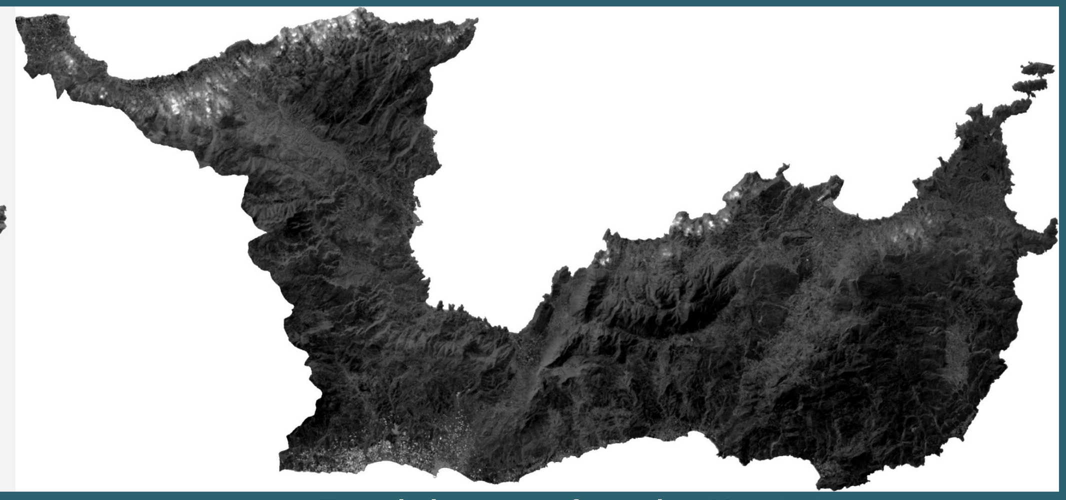
NDVI 11-9-2000



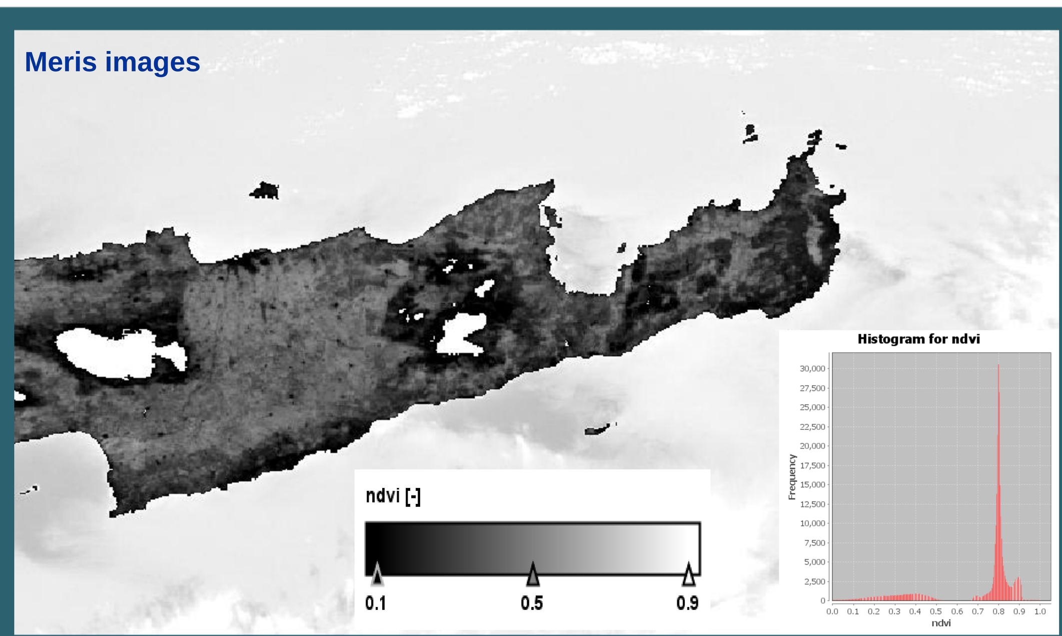
NDVI 26-9-1985



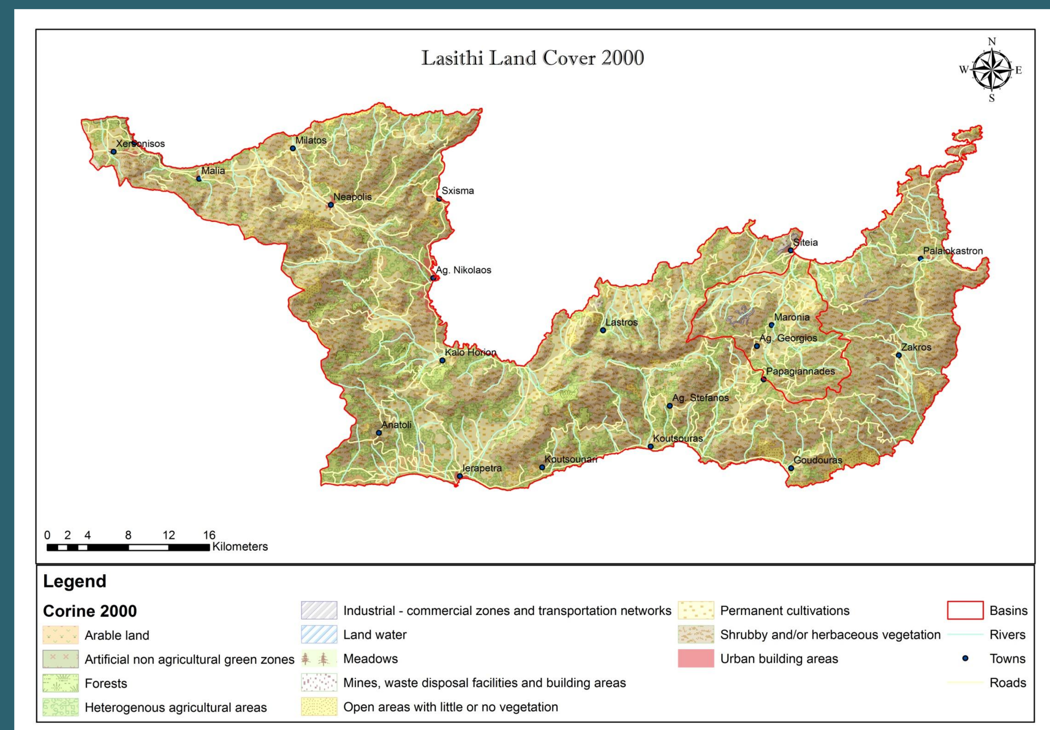
Tasseled cap transformation 26-9-1985

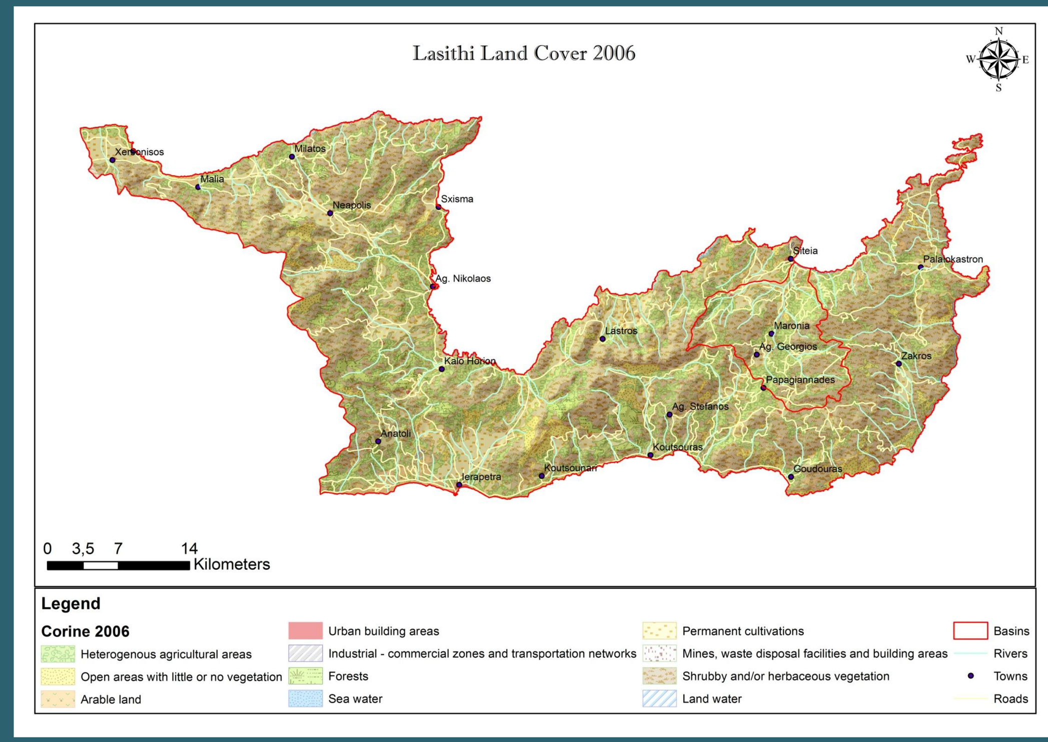


Tasseled cap transformation 11-9-2000



3. Land Cover data (Corine 2000-2006)





4. Desertification

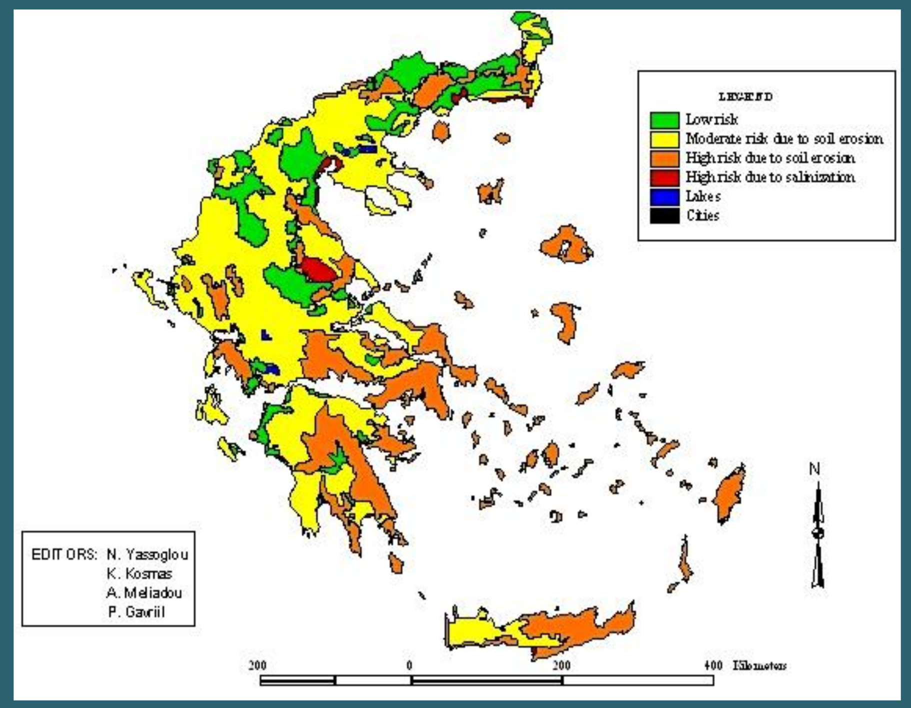
As concluded in the relevant UN Convention in 1994, desertification has affected large areas within the European Mediterranean coastal regions and is threatening even larger territories.

Desertification as a means of land degradation can be resulted from a series of factors including climatic changes and anthropogenic activities; while appears more pronounced in arid and semi-arid areas.

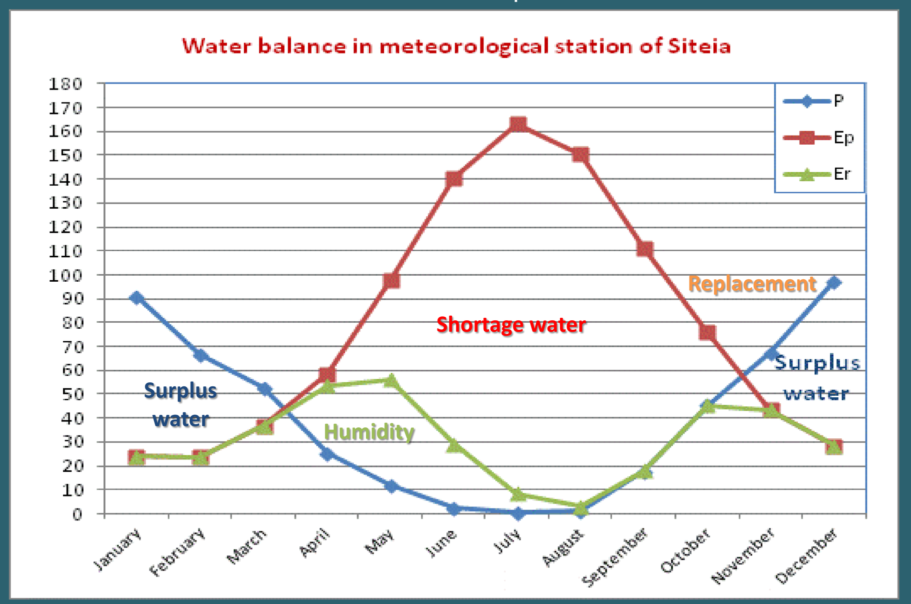
With special reference to Greece, it is estimated that more than 35% of the country's surface area shows high risk of desertification; with the island of Crete having the highest potential for such environmental hazard. More specifically over 50% of the island is exposed to high desertification potential, especially in areas located at the south-eastern part.

The climate is semi-arid, with ephemeral rainfall events which are unevenly distributed in spatial as well as time extent. The average precipitation (P) is approximately 478 mm and the evaporation is 368 mm (77%) -average temperature is 18.7ºC- while the sum of runoff and percolation is app. 110 mm (23%).

On the other hand, the majority of the coastal aquifers are subjected to overexploitation (groundwater used for irrigation purposes). These conditions have led to encroachment of seawater towards the coastal aquifers. As brackish groundwater is used for irrigation purposes, this consequently results in salt accumulation on the soil surface, fact which severely degrades the soil by increasing salinity.



Desertification risk map of Greece



5. Conclusions

Considering the hydrological and satellite images data, the area of Eastern Crete, also according to the Greek Committee of Desertification, is a high-risk area. This is due to the following factors:

Soil: because of the erosion, salinization and drying of soils, there is inability of covering vegetation needs in water.

- Geological: limestones covering the biggest part of the study area, contribute to desertification due to permeability
- Physiography: existence of intense topographic gradients
- Hydrological: Significant losses by surface runoff and groundwater flow to the sea.
- Climatic: The area is included in the semi-dry climate zone according to the separation of FAO-Unesco (P / Etp = 0,5). It is characterized by small rainfall, high evapotranspiration, uneven distribution of rainfall, high intensity and high corrosivity, high moisture deficit (water balance diagram), high temperatures.
- Anthropogenic: overexploitation of water resources, urban construction and development of tourism, sea intrusion in coastal aquifers, due to over-pumping .

6. References

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