CASCADE STUDY AREA 5: Messara Valley, Crete, Greece

Responsible partner: TUC

1. General information

The rapid development of Crete in the last 30 years has exerted strong pressures on many sectors of the region. The growth of agriculture in the Messara plain has strong impact on the water resources and ecosystem services of the area by substantially increasing water demand. The economy of the region is based on agriculture with intensive cultivation: mainly olive trees, grapes, citrus, and vegetables in green houses. The village Perion and its surrounding area was chosen as the study site for CASCADE experiments. The area is located at the boundary of the largest aquifer of Crete, at the foot of the Asterousia Mountains. The environment has the typical wild characteristics of Crete and receives natural pressures mainly due to the dry climate. Human pressures include interference with the natural water balance due to agricultural water pumping and overgrazing.

2. Geographical description

The Messara Valley covers an area of 398 km^2 with a mean altitude of 435 m. Messara comprises of a plain with east-west orientation, about 25 km long and 5 km wide, with a total area of 112 km^2 and hedged with mountains on the north and south sides (Figure 1). The geomorphological relief is typical of a graben formation and the surface drops within 15 Km from 2,454 m asl on Psiloritis Mountain to 45 m asl at Festos. The Geropotamos River with a westward direction and the Anapodaris River with an eastward direction drain the homonymous catchments. The catchment area of the northern slopes is 160 km^2 while the southern slopes constitute a catchment area of 126 km^2. To the north, the divide varies from 1700 to 600 m from west to east, with the highest point being part of the Ida mountain range (peak at 2540 m). The Asterousia mountain chain lies in the south and rises 600 m in the west to 1200 m in the east and constitutes the southernmost mountain range of Europe. At the east part of the Valley is the catchment of Charakas, and to the west of the Valley flows the Geropotamou River, forming the catchment of Phaistos, where it meets a constriction at an outlet at 30m asl.

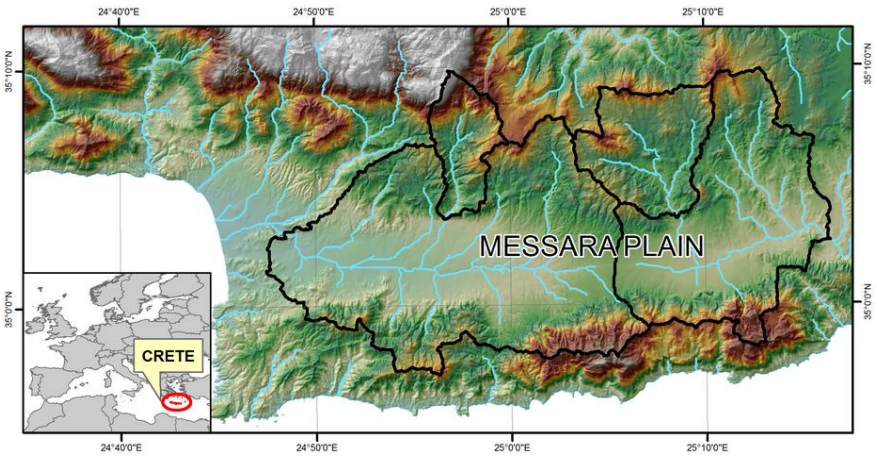

Figure 1: Location of the Messara basin and plain

3. Main ecosystem(s) in the study area and functions/services they provide

Two main agro-ecological zones occur in the Messara region: the hilly zone, surrounding the plain, and the plain itself. These zones have different agro-ecological characteristics. The Messara landscape has been in cultivation for thousands of years. About 30% of the flora of Crete is linked to agriculture and around 200 species are imported with agricultural systems from abroad. Nowadays Cretan farming systems are specialized monocultures, with olive groves both in the hills and in the plain, while vines remain in limited areas.

While 250 km^2 of the total Valley area are cultivated, the remaining area has mostly semi-natural vegetation and is used for livestock. An important part of the flora ecosystem is the wild evergreen maquis/phrygana which is the most common and most characteristic vegetation in Crete. It is found predominantly from 0 to 600 m, but may reach about 1000 m. Two major units are recognized; a community with *Pistacia lentiscus* and *Ceratonia siliqua* grows in the lower zones and the coastal plains, always together with *Olea europaea* and a vegetation *of Quercus coccifera* with *Q. ilex*, limited to altitudes between 300 and 1000 m. Today, a large number of animals such as sheep, goats, and cows are scattered throughout the hilly and mountainous areas grazing and sometimes overgrazing the land. Nevertheless, herbivores have to commute towards the plain during the cold months due to low temperatures and low grazable biomass. While there are no detailed statistics at the scale of the study site, livestock on the island is estimated at 1700mil animals, facing a decline due to the rise in fodder price in relation to the current financial crisis.

4. Ecosystem dynamics

Experts assess that the Messara Valley is threatened with desertification. Figure 3 shows evidence of the dramatic drop of more than 30m in the mean groundwater level during the period 1989-2002. The depletion of the aquifer has reduced water availability as groundwater is a major resource for irrigation. The causes can be traced in the uncontrolled pumping and use, and this has created tension amongst the users. The groundwater level drop started with the introduction of pumping of the groundwater store for drip-irrigation of the main crop which is olive trees. The impact of groundwater abstraction on the ecosystem of the watershed became obvious when the springs in the surrounding hills dried up and the natural flora and fauna of the environment around these springs perished, with the loss of birds, small animals and flowers. Further to the west, the aquifer of the 50 km^2 coastal Tymbaki basin consists of Pleistocene to Holocene alluvial deposits and is block faulted by post Upper Pleistocene normal faults. Simulation of seawater intrusion, has established that at the southern end of the coast, by the Geropotamos stream alluvial recharge zone, the toe of the saltwater intrusion front lies 550 to 600 m inland from the coastline. At the northern end of the coast, the toe of the saltwater intrusion front is located 1500 m inland from the coastline. The Geropotamos stream is by the far the most important water supplier to the Tymbaki aquifer and as such, regulates both seawater intrusion extent and pattern.

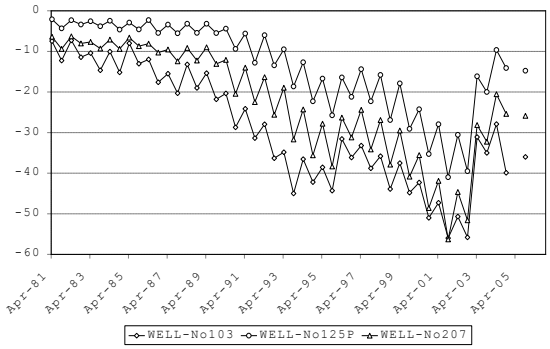

Figure 2: Seasonal Data from 3 wells in the Messara aquifer

One of the adverse effects of monocultures in the plains is the gradual degradation of the natural environment through the reduction of biodiversity (Figure 3). On higher ground biodiversity is endangered by the free grazing of sheep and goats as there are areas that are overgrazed. It is worth noting that traditional grazing practices follow a sustainable model that promotes biodiversity, controls forest encroachment and averts the abandonment of the countryside. An indicator of overgrazing is the consumption of less palatable or poisonous species by herbivores, a sign that the vegetation biomass is not sufficient for sustaining their density.

Figure 3: Messara Valley – partially grazed pastureland next to olive tree monocultures near the village of Perion

5. Proposed experiments

The problem of overgrazing in the area of Messara will be investigated, as it has been documented by various studies. The experiment can be summarized in the selection of three different stages of ecosystem degradation due to overgrazing. Fieldwork has established that the selected vegetation comprising of a local tussock grass variety and a wild pear tree can be found at different stages of grazing throughout the area, depending on their location with respect to the livestock grazing grounds. Underlying soil formations are mostly neogene sediments and flysch that are both characterized by a relatively high runoff. During the first year of the experiments vegetation growth and soil properties will be analyzed in order to establish a reference for the existing ecosystem characteristics at different degradation stages. Starting from the second year, the drought in the study site will be prolonged artificially for varying periods using raised canopy structures. The goal of

this experiment is to measure the vegetation and soil behaviour under conditions of climatic stress and to detect potential indicators of sudden catastrophic shifts in the ecosystem.

6. Relevant end-users of knowledge in the region / country

- Directorate of Agriculture Development, Region of Crete
- Directorate of Environmental and Spatial Planning, Region of Crete
- Directorate of Water Resources Management, Region of Crete: is the main authority in change of planning, policy making and development of public infrastructure in the Region of Crete
- Directorate of Regional Forestry, Region of Crete
- Directorate of Civil Protection, Region of Crete: is the main authority in charge of planning and information dissemination regarding potential adverse environmental impacts for the local society.
- Local municipal departments
- Pastoralists' Union of Heraklion: represents the main user of the pastureland of the Prefecture of Heraklion including the study area. The users (pastoralists) benefit from the natural biomass production (grazable vegetation) as it is an inexpensive fodder for their herbivores.

7. Anticipated activities and workshops with stakeholders

- Stakeholder meeting on 10/30/2012 with participants TUC, the President of the Pastoralists' Union of Heraklion and the Director of the Civil Protection Agency of the Region of Crete. On behalf of the Pastoralists' Union, the meeting agenda included information on pastoralism practices, statistics, the importance of the natural environment and its management for the pastoralists, awareness of the problem of overgrazing, problems, future goals, scenarios and planning.
- The first field trip for data collection took place in November 2012.

8. Past and on-going projects on ecosystem functioning, thresholds, and related aspects

- FAO. 1972c Overall Study of the Messara Plain. Report on Study of the Water Resources and their Exploitation for Irrigation in Eastern Crete. FAO Report No. AGL:SF/GRE/31.
- Dietrich G. and Kilakos J. 1971 Groundwater quality in the Messara Plain in Eastern Crete, Greece. Working Document No. 18. FAO/UNDP/AGL:SF/GRE 17.
- MESSARA, An integrated monitoring and modeling study of desertification and climatic change Impacts in the Messara Valley of Crete, ENVIRONMENT Program, EU, DG-XII, 1994-96
- Yassoglou N., 1971. A study of the soil of Messara valley in Crete, Greece. Greek Nuclear Research Centre, Athens, Greece.

- EU research project Grapes – Groundwater and River Resources Programme on a European Scale. Contract ENV4 – CT 95 – 0186, DG XII, February 1996
- National research project BEWARE - Best Water Use Innovative Practices towards a Sustainable Water Resources Management, (CRINNO) (2002-2005)
- MEDIS - SIMULATION OF SEAWATER INTRUSION INTO THE TYMBAKI AQUIFER, SOUTH CENTRAL CRETE, GREECE, Savvas N. Paritsis. (EVK1-CT-2001-00092(, (2002-2006)
- EU research project HarmoniRiB – Harmonised Techniques and Representative River Basin Data for Assessment and Use of Uncertainty Information in Integrated Water Management (EVK1-CT-2002-00109) (2002-2006).
- DESIRE FP6: Desertification mitigation and remediation of land - a global approach for local solutions. SUSTDEV-3 Global change and ecosystems,SUSTDEV-2005-3.IV.1.1, (2007-2012). (Figure 4) See http://www.desire-project.eu/

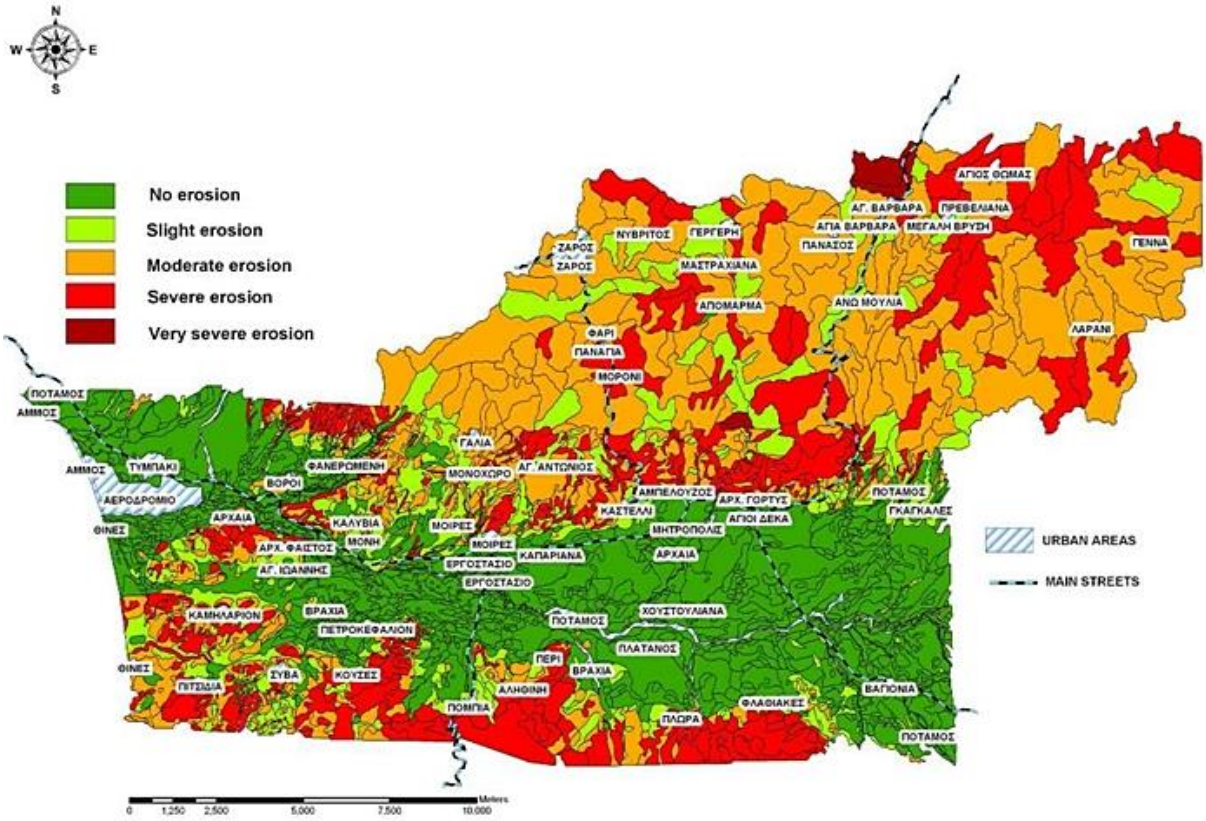

Figure 4: Degree of soil erosion estimated during the soil survey of the Messara valley

9. Key references about ecosystem dynamics in the study area or wider spatial setting

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2. Koutroulis A.G., Vrochidou A., **Tsanis I.K.**, "Spatial and temporal characteristics of droughts for the island of Crete", Journal of Hydrometeorology, 12, 2 206-226, 2011.
3. M. Kritsotakis and I.K. Tsanis, An integrated approach for sustainable water resources management of Messara Basin, Crete European Water 27/28:15-30, 2009.
4. **Tsanis, I.K.**, M. G. Apostolaki, "Estimating Groundwater Withdrawal in Poorly Gauged Agricultural Basins", Water Resources Management, 23(6):1097-1123, 2009.
5. Daliakopoulos, I., Coulibaly P. and **Tsanis, I.K.**, "Groundwater Level Forecasting Using Artificial Neural Networks", Journal of Hydrology, 309, 229-240, 2005.
6. Naoum, S and **Tsanis, I.K.,** "Orographic Precipitation Modelling with Multiple Linear Regression", Journal of Hydrologic Engineering, ASCE, 9(2), 79-102, March 2004.
7. Naoum, S., and **Tsanis, I.K.,** "Temporal and Spatial Variation of Annual Rainfall on the Island of Crete, Greece", Hydrological Processes, 17, 1899-1922, 2003.
8. **Tsanis, I.K**., Koutroulis A.G., Daliakopoulos, I.N., D. Jacob., "Severe Climate-Induced Water Shortage in Crete", Climatic Change Letters, 2010 (submitted)
9. **Tsanis I. K**., P. Coulibaly, I. N. Daliakopoulos, 2008. Improving groundwater level forecasting with a feedforward neural network and linearly regressed projected precipitation. Journal of Hydroinformatics 10 (4) 317–330
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