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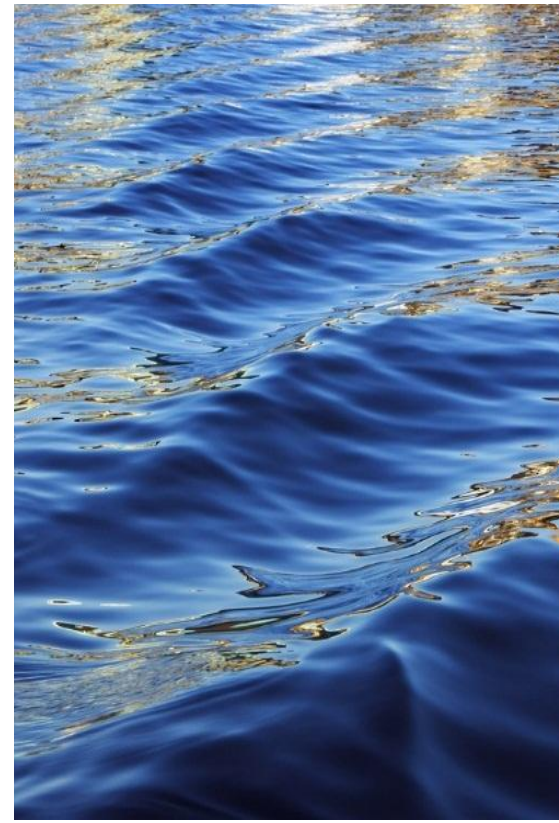
ILHAM-EC

Mobility strand for teachers in Greece

Thessaloniki, 22-26 May 2017



ILHAM-EC
Interuniversity Learning in Higher Education on Advanced land Management

ARISTOTLE UNIVERSITY OF THESSALONIKI

Faculty of Agriculture

Co-funded by the Erasmus+ Programme of the European Union

Development of a national geodatabase (Greece) for soil surveys and land evaluation using space technology and GIS

Assessing the impacts of wastewater reuse for irrigation using soil quality index

Dr. George Bilas

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Faculty of Agriculture

Development of a national geodatabase (Greece) for soil surveys and land evaluation using space technology and GIS

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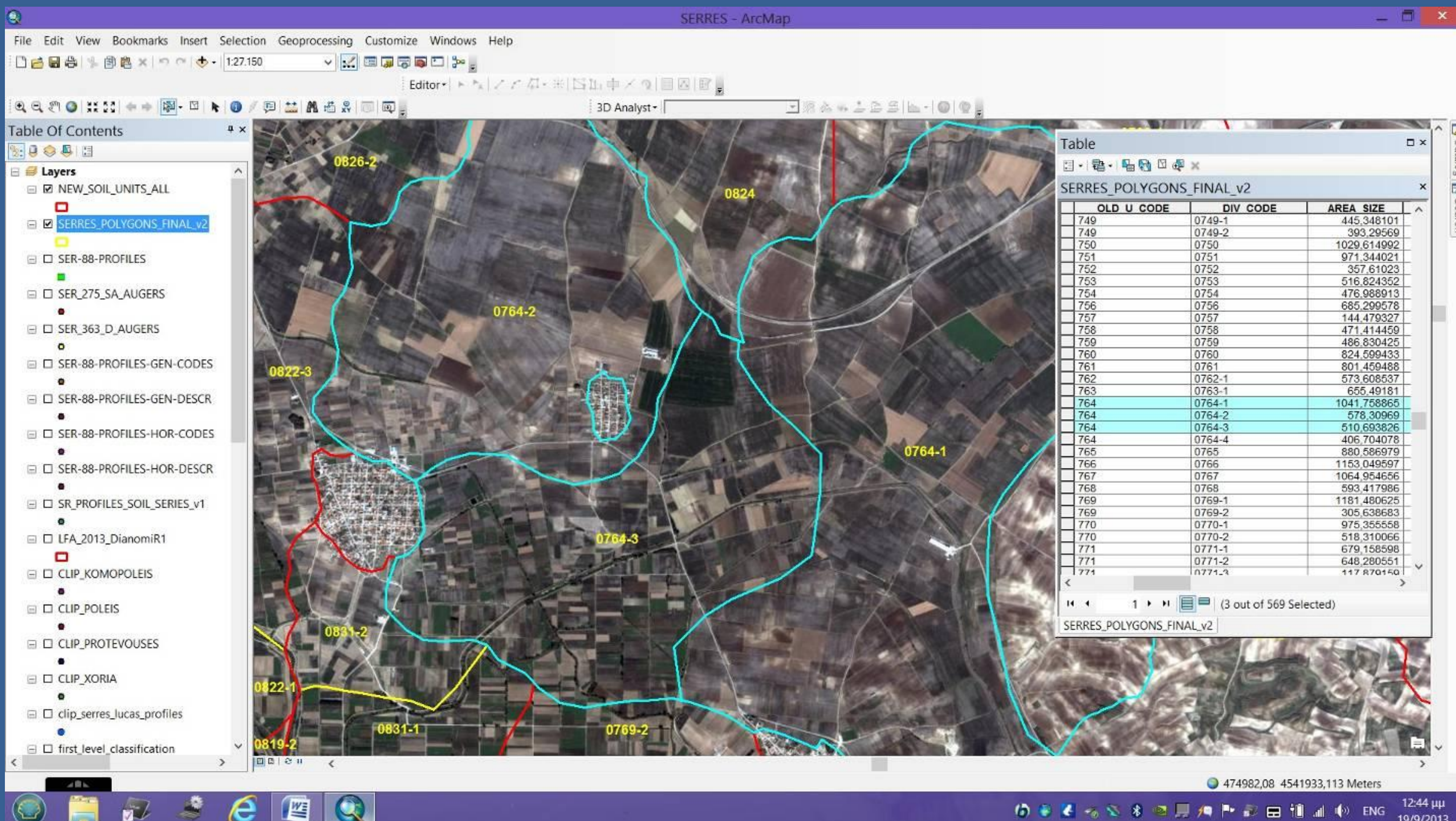
Introduction

- The project was funded by Payment and Control Agency for Guidance and Guarantee Community Aid (OPEKEPE) of the Greek Ministry of Agricultural Development and Food.
- It involves development of a national geodatabase and a WebGIS that encompass soil data of all the agricultural areas of Greece in order to supply the country with a multi-purpose master plan for agricultural land management.
- The study area covered 385,000ha which is the sum of the country’s agricultural land. It commenced in 2013, and work was carried out in 24 months, requiring a high level of scientific coordination and efficiency. The consortium consisted of “Aristotle University of Thessaloniki”, and “Elpho”, a private Greek company, and the scientific coordinator of the whole project was Professor Emeritus N. Misopolinos.

Soil physiography

Using satellite images, the study area was delineated in more than 9.000 Soil Mapping Units (SMU) based on existing information layers regarding soil formation, 3D landscape observation, physiographic analysis, field work and photo interpretation.

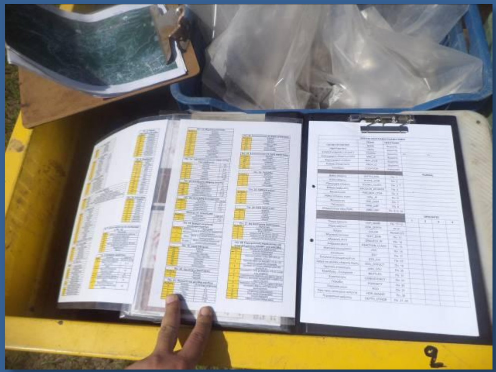


Soil sampling and analysis

- Sampling was performed using hydraulic soil samplers mounted on trailers. Each field team included one Soil Scientist, one technician for operating the sampler, and one navigator specialized in using maps and tablets with navigation system and GPS to enable rapid and accurate routing and identification of sampling points.
- In total, 2,000 soil profiles were excavated, described and sampled and 8,000 soil cores were sampled in two depths (0-30 and 30-60 cm).

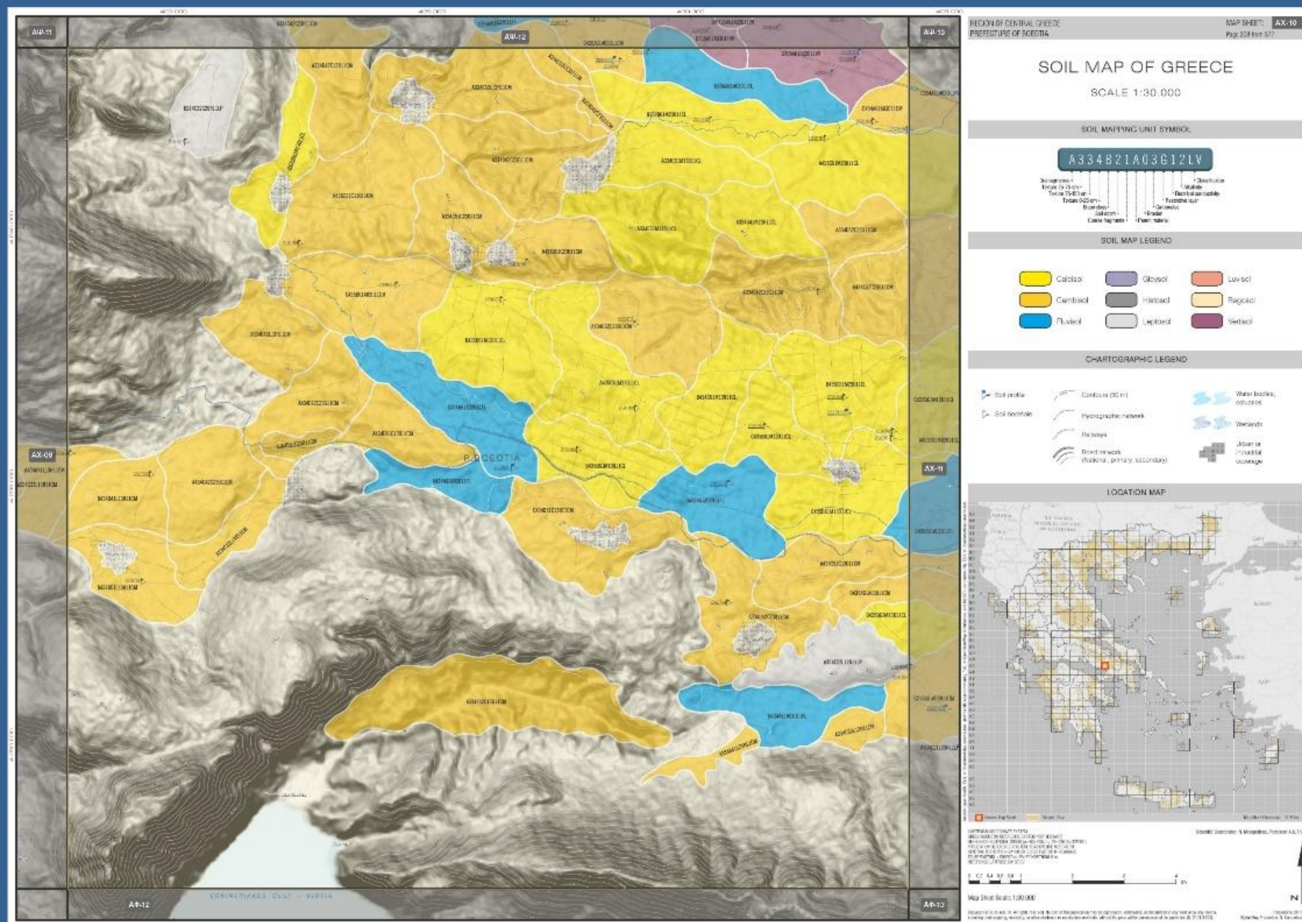
Soil database

- The number of soil samples analyzed was over 22.000 analysis, and 22 soil properties were determined (physical and chemical) according to ISO standards 11464: 2006 and ISO/IEC 17025: 2002.
- All the soil data collected were introduced in a GIS database, after thorough scrutinization from soil science experts. The classification system of FAO was used and SMUs were finalized.



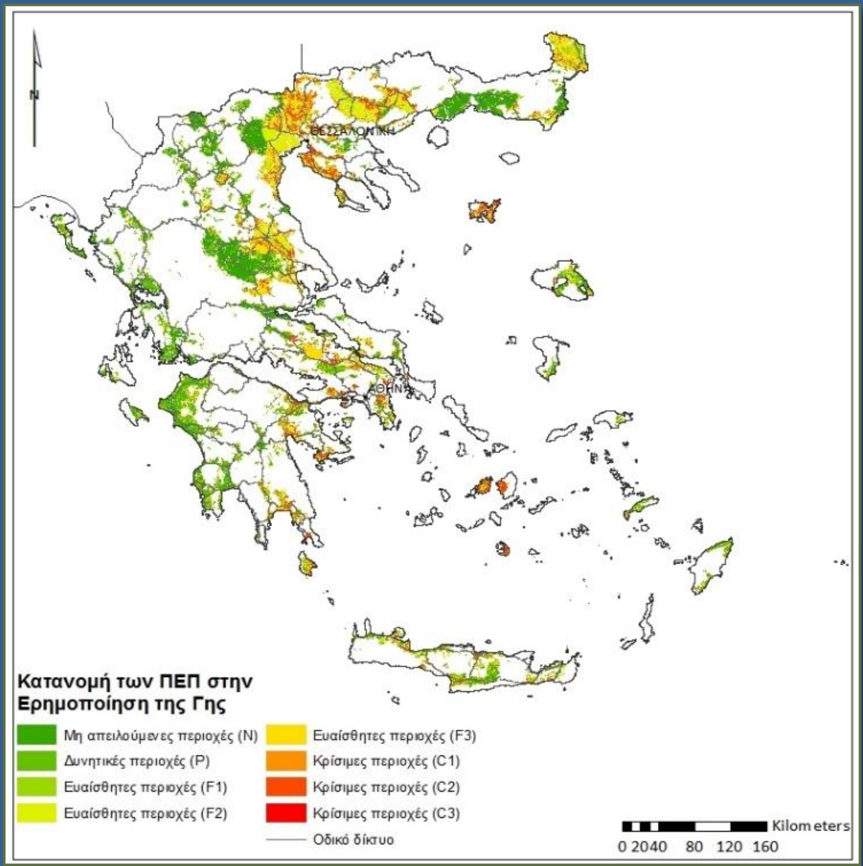
e-SoilBook

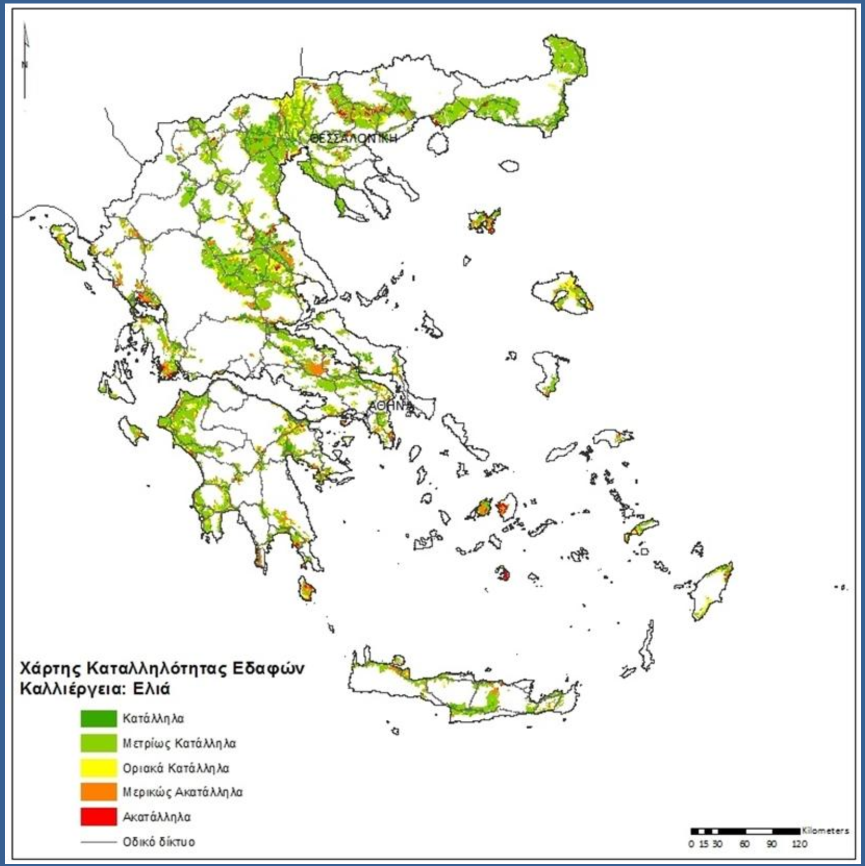
Apart from the digital soil database, an A3 size soil book was created in pdf format for fast tracking and visualization of project's products. The book includes 570 soil maps in 1:30.000 scale which cover the agricultural areas of Greece.



Risk assessment and land suitability maps

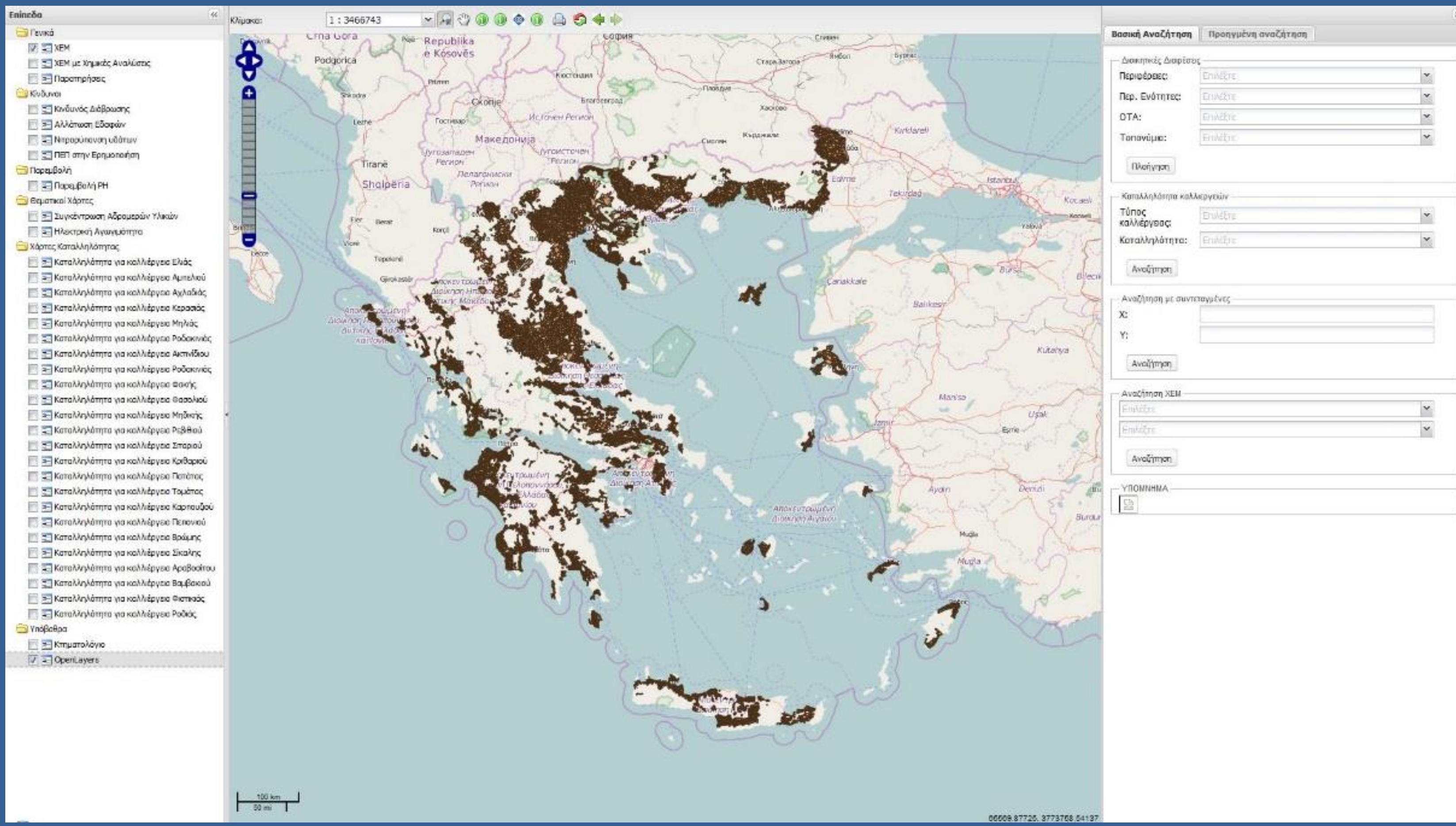
Risk assessment maps were produced, after incorporating several layers of information, regarding salinity, erosion, nitrates, and desertification into the soil database. Furthermore, taking into account plant needs of 30 crops, land suitability maps were developed in order to facilitate agricultural production and crop allocation.





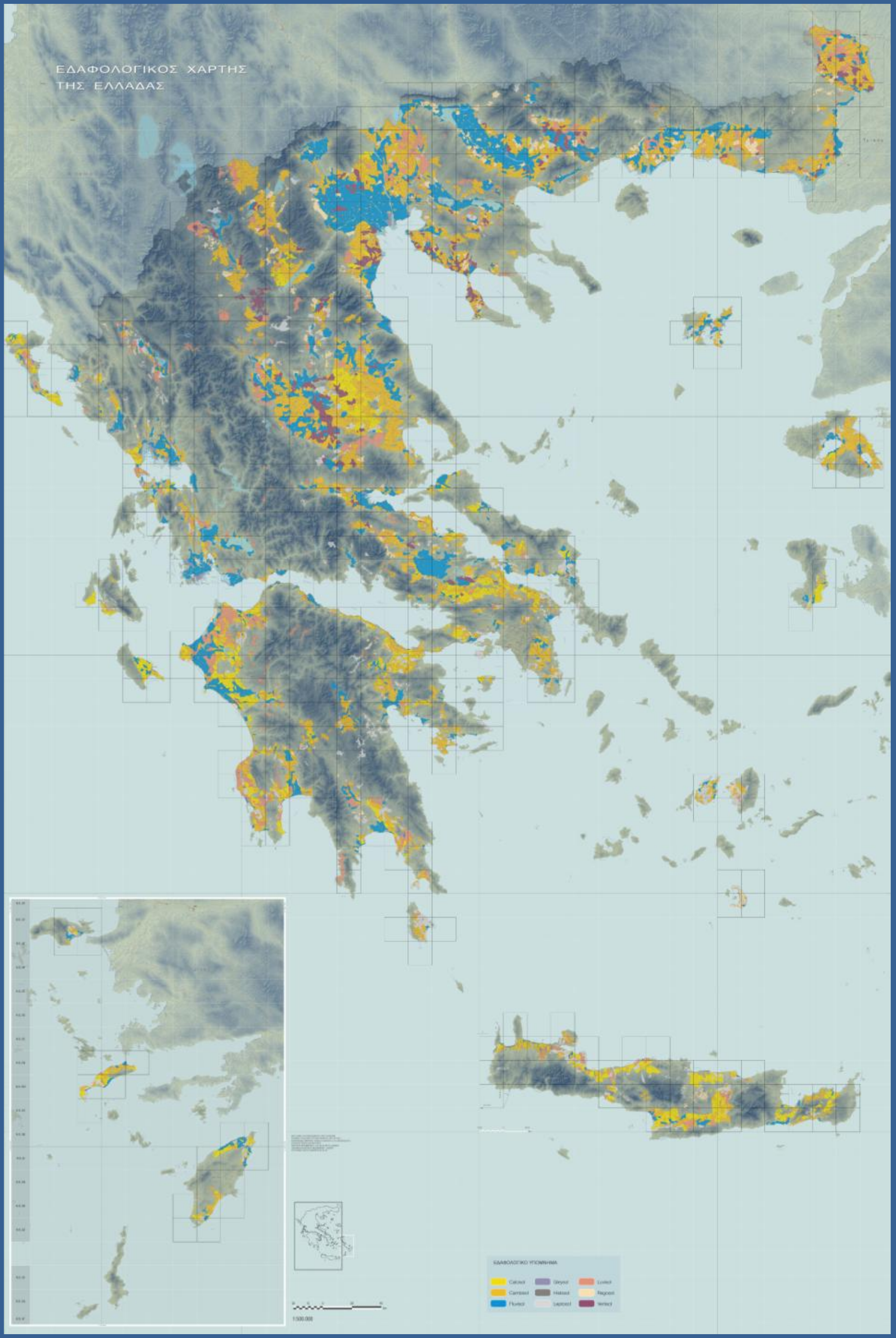
WebGIS

The attribute data and the thematic maps, such as FAO taxonomic units, erosion, salinity, alkalinity, desertification and nitrates risks maps were introduced in a WebGIS system for private and public stakeholders.



The integrated system is expected, after being fully operational, to provide important electronic services and benefits to farmers, private sector and governmental organizations.

Soil map of Greece 1:30,000



Assessing the impacts of wastewater reuse for irrigation using soil quality index

Dr. George Bilas

Introduction

- Wastewater reuse for irrigation not only prevents overexploitation and degradation of water resources, but also provides essential nutrients (e.g. nitrogen and phosphorus) for crops
- However, there are cases where high salt and trace elements concentrations in reclaimed wastewater may have adverse effects on soil quality and plant growth

Introduction

- Soil quality is defined by the performance of soil functions, which in turn are determined by measuring a set of physical, chemical and biological parameters/indicators
- Soil quality is a component of agro-ecosystem sustainability and management

Objectives

The overall objective of this work was to quantify soil quality using SQI in order to comparatively assess the impact of wastewater reuse for irrigation. Specific objectives were:

a) to assess the impacts of different irrigation wastewater qualities on soil quality, and

b) to quantify soil quality using a procedure consisting of a simple normalizing method to assign scores to treatment values of the most relevant indicators of local ecological conditions.

Materials and methods

- 6-year experimental field under conventional farming located near Gallikos River in northern Greece
- Crop rotation included sugar beets (Beta vulgaris), cotton (Gossypium hirsutum L.) and maize (Zea mays ssp. Mays)
- Wastewater was applied by a drip irrigation system
- Experimental design was completely randomized, with six replicates per treatment.

Water qualities applied

- Fresh water provided by an irrigation well (Tf)
- Wastewater that received a secondary biological treatment and disinfection of the outflow (Tp)
- Wastewater that received a secondary treatment in a series of lagoons without disinfection of the outflow (Tl)

	Tf	Tp	Tl
pH	7.58 (0.12)	7.69 (0.21)	7.99 (0.18)
EC (dS/m)	1.07 (0.05)	4.00 (0.23)	5.88 (0.32)
K^+ (cmoles/L)	0.09 (0.01)	1.02 (0.12)	1.39 (0.34)
Na^+ (cmoles/L)	2.56 (0.25)	29.89 (3.46)	41.45 (7.22)
Ca^{++} (cmoles/L)	5.15 (0.45)	4.79 (0.98)	5.44 (1.12)
Mg^{++} (cmoles/L)	4.07 (0.95)	6.99 (2.77)	10.60 (1.67)
SAR	1.19 (0.17)	12.22 (2.16)	14.66 (3.45)
BOD_5 (mg/L)	1.0 (0.01)	20.0 (3.28)	31.5 (5.32)

Soil sampling and analysis

Soil samples for physical and chemical analyses were collected from top soil layer. Measurements included:

- Texture
- Bulk density from intact soil cores
- Water-filled pore space was calculated
- Infiltration rate in the field
- pH and EC in saturation extract
- Soluble K^{+}, Na^{+}, Ca^{++}, and Mg^{++}
- SAR was calculated
- TOC by wet combustion method
- Soil respiration in the field

Results

Indicator	Treatment Tf	Tp	Tl
Bulk density (g/cm3))	1.28 (0.05)	1.28 (0.05)	1.24 (2.28)
Infiltration rate (mm/hr)	61.1 (38.6) a	14.1 (8.0) b	13.7 (11.4) b
Water filled pore space (%)	30.1 (1.4) c	41.4 (5.7) b	42.9 (9.1) a
pH	7.72 (0.31) b	8.30 (0.19) a	8.50 (0.28) a
EC (dS/m)	1.15 (0.09) c	3.99 (0.86) b	5.22 (1.36) a
TOC (Mg/ha)	9.98 (0.07)	9.98 (0.09)	9.30 (0.24)
SAR	1.74 (0.40) c	8.74 (1.23) b	10.59 (2.40) a
Soil respiration (kg C/ha/d)	2.70 (1.02) b	7.58 (1.51) a	7.79 (1.55) a

Values within a row for an indicator followed by a different letter are significantly different at $p \leq 0.05$ using the Fisher's protected LSD

Quantification method

$$SQI = \text{Nutrient Relations} \times W_1 + \text{Water Relations} \times W_2 + \text{Rooting Environment} \times W_3$$

where W_1, W_2, W_3 are the weighting factors of soil functions and $W_1+W_2+W_3 = 1$

Quantification method

Nutrient Relations (NR) = pH x w_1 + EC x w_2 + TOC x w_3 + Soil respiration x w_4

Water Relations (WR) = Bulk density x w_1 + Infiltration rate x w_2 + Water filled pore space x w_3

Rooting Environment (RE) = Bulk density x w_1 + pH x w_2 + EC x w_3 + SAR x w_4 + Soil respiration x w_5

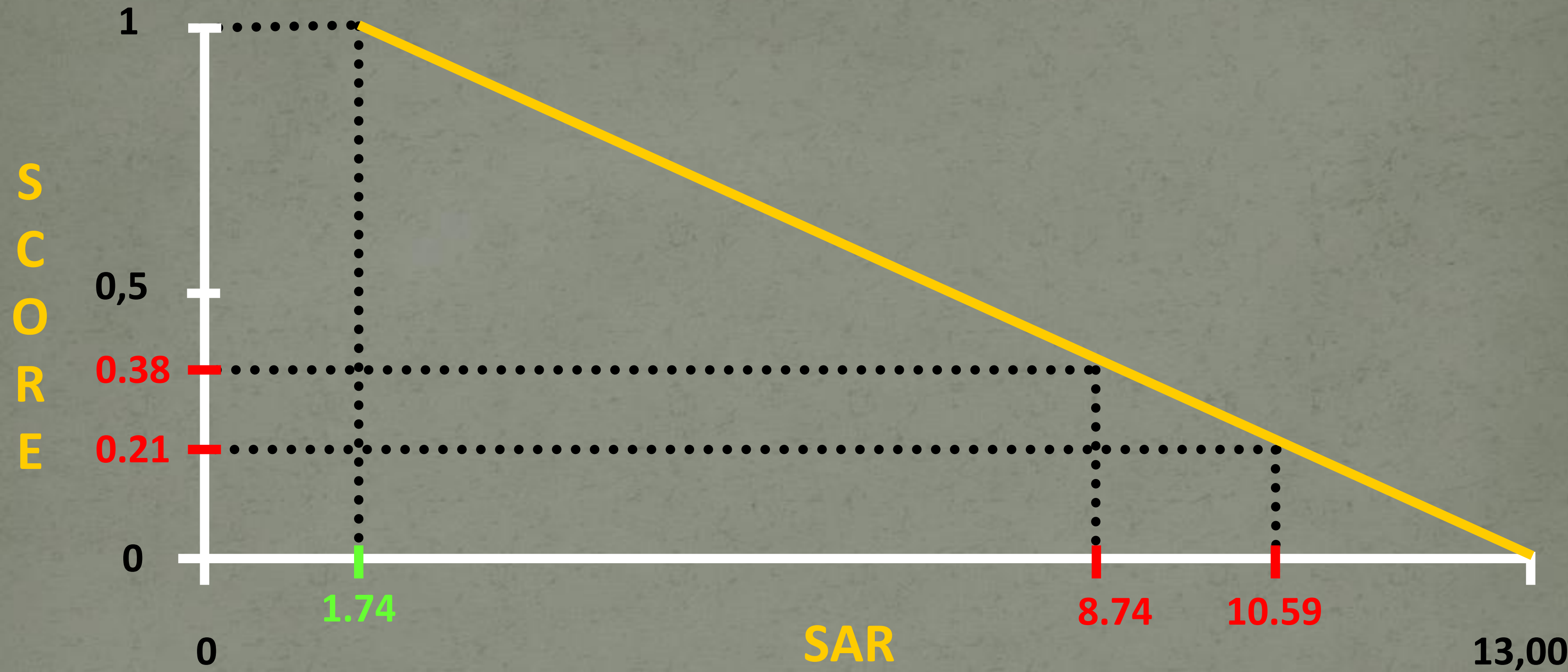
where w_1, w_2,… w_n are weighting factors and for each function $w_1+w_2 + … + w_n = 1$.

Selected threshold values and rules of change

Indicator	Lower threshold	Optimum	Upper threshold	Rules of change
Bulk density (g/cm3)		1.24	2.00†	Less is better
Infiltration rate (mm/hr)	0†	61.1		More is better
Water filled pore space (%)	15.0†	42.9		More is better
pH		7.72	8.50‡	Less is better
EC (dS/m)		1.15	2.00†	Less is better
TOC (Mg/ha)	0.00†	9.98		More is better
SAR		1.74	13.00§	Less is better
Soil respiration (kg C/ha/d)	0.00#	7.79		More is better

†Values adopted after Glover et al. (2000)
‡ pH values greater than 8.5 denote that the soil is sodic (USDA, 1954)
§ SAR values greater than 13 denote that the soil is saline (USDA, 1954)
# Soil respiration 0 value denotes no microbial activity (Parkin et al., 1996)

Normalizing procedure - Scoring



	Treatment		
Indicator	Tf	Tp	Tl
SAR	1.74 (0.40) c	8.74 (1.23) b	10.59 (2.40) a

Calculated normalized values

Indicator	Tf	Tp	Tl
Bulk density (g/cm3)	1.00	1.00	1.00
Infiltration rate (mm/hr)	1.00	0.23	0.22
Water filled pore space (%)	0.54	0.95	1.00
pH	1.00	0.00	0.00
EC (dS/m)	1.00	0.00	0.00
TOC (Mg/ha)	1.00	1.00	1.00
SAR	1.00	0.38	0.21
Soil respiration (kg C/ha/d)	0.35	0.97	1.00

Scores of soil functions and SQI

Treatment	Soil Functions			SQI
	Nutrient Relations	Water Relations	Rooting Environment	
Tf	0.84	0.85	0.87	0.85
Tp	0.56	0.73	0.52	0.60
Tl	0.50	0.74	0.44	0.56

Conclusions

- The SQI for the three treatments indicated that there was an impact on soil quality when wastewater was reused for irrigation.
- The proposed method for calculating normalized values for measured soil indicators is easy to use and requires selection of threshold values that should not be exceeded.
- Optimum values have been assigned to indicators based on the desired rule of change relative to the reference treatment, since quantification of soil quality is comparative.

Conclusions

- The scoring procedure described was effective at quantifying soil quality for different treatments. The proposed procedure amplifies differences when measured values are close to selected threshold levels, thus making it able to assess impacts that can possibly degrade soil quality.
- The indicators to be measured must be carefully selected to represent local ecological conditions.
- Caution has to be exercised when applying wastewater for irrigation and site specific adaptive soil management has to be taken into consideration to avoid soil degradation.

THANK YOU

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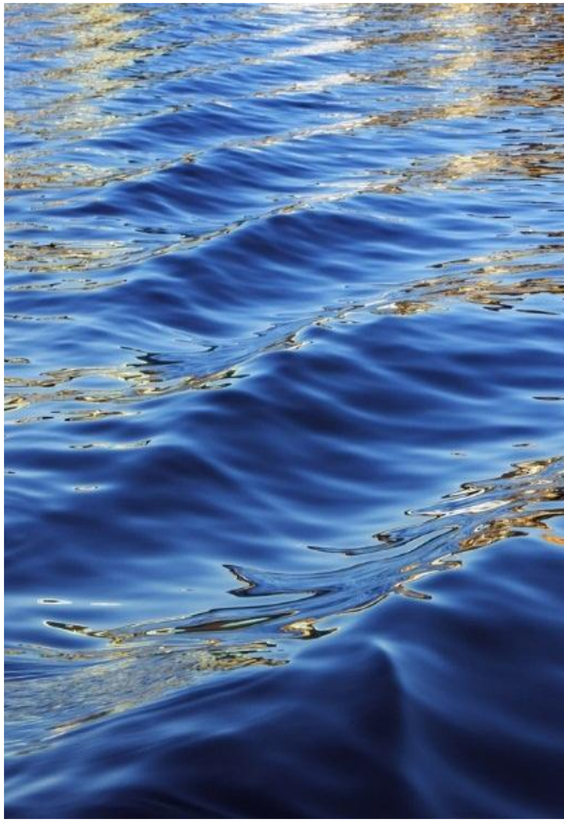

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