ILHAM-EC

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Minimum Data Set and Mapping of Soil Quality

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MINIMUM DATA SET

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MINIMUM DATA SET

- Assessment of soil quality is the basis for assessing sustainable soil management in the next century. It is particularly difficult to select factors of soil quality for degraded or polluted soils.
- Dumanski (1994) indicated that appropriate sustainable management would require that a technology have five major pillars of sustainability, namely, it should:
- (1) be ecological protective
- (2) be socially acceptable
- (3) be economically productive
- (4) be economically viable
- (5) reduce risk

MINIMUM DATA SET

- Appropriate indicators are needed to show whether those requirements are being met. Some possible soil variables which may define resource management domains are soil texture, drainage, slope and land form, effective soil depth, water holding capacity, cation exchange capacity, organic carbon, soil pH, salinity or alkalinity, surface stoniness, fertility parameters, and other limited properties (Eswaran *et al.* 1998).
- The utility of each variable is determined by several factors, including whether changes can be measured over time, sensitivity of the data to the changes being monitored, relevance of information to the local situation, and statistical techniques which can be employed for processing information.

MINIMUM DATA SET

- Doran and Parkin (1994) have developed a list of basic soil properties or indicators for screening soil quality and health.
- Physical indicators including (1) soil texture, (2) depth of soils, topsoil or rooting, (3) infiltration, (4) soil bulk density, and (5) water holding capacity.
- Chemical indicators including (1) soil organic matter (OM), or organic carbon and nitrogen, (2) soil pH, (3) electric conductivity (EC), and (4) extractable N, P, and K.
- Biological indicators including (1) microbial carbon and nitrogen (2) potential mineralizable nitrogen (anaerobic incubation) and (3) soil respiration, water content, and soil temperature.
- Harris and Bezdicek (1994) indicated that soil quality indicators might be divided into two major groups, analytical and descriptive. Experts often prefer analytical indicators, while farmers and the public often use descriptive descriptions. Soil contaminants selected as indicators may be those which have an impact on plant, animal and human health, or soil function.

MINIMUM DATA SET

- There is a need to develop soil quality indicators in such a way so that they (Doran and Parkin, 1994):

(i) integrate soil physical, chemical and/or biological properties and processes,

(ii) apply under diverse field conditions,

(iii) complement either existing databases or easily measurable data, and

(iv) respond to land use, management practices, climate and human factors.

MINIMUM DATA SET

- The selection of indicators should be based on:

  - the land use;

  - the relationship between an indicator and the soil function being assessed;

  - the ease and reliability of the measurement;

  - variation between sampling times and variation across the sampling area;

  - the sensitivity of the measurement to changes in soil management;

  - compatibility with routine sampling and monitoring;

  - the skills required for use and interpretation.

MINIMUM DATA SET

- **Inherent**, or use-invariant, soil properties change very little or not at all with management. Inherent soil properties form over thousands of years and result primarily from the soil forming factors: climate, topography, parent material, biota, and time.
- Examples of inherent properties are: soil texture, type of clay, depth to bedrock, and drainage class.

- **Dynamic**, or management dependent, soil properties are affected by human management and natural disturbances over the human time scale, i.e., decades to centuries. Significant changes in dynamic soil properties can occur in a single year or growing season.
- Examples of dynamic soil properties are mainly nutrients such as N, P, K.

MINIMUM DATA SET

- Soil quality indicators are normally chosen according to the research focus.
- The dataset of indicators may be constructed according to
- expert opinion (Andrews et al., 2002; Sánchez-Navarro et al., 2015), based on how often the parameters appear in scientific papers (Rousseau et al., 2012),
- or it may be guided solely on statistical criteria.
- Certainly, it can also consist of the combination of both strategies (Lima et al., 2013).

CASE STUDY

IMPACT OF SOIL QUALITY ON WINE PRODUCING GRAPE VARIETIES

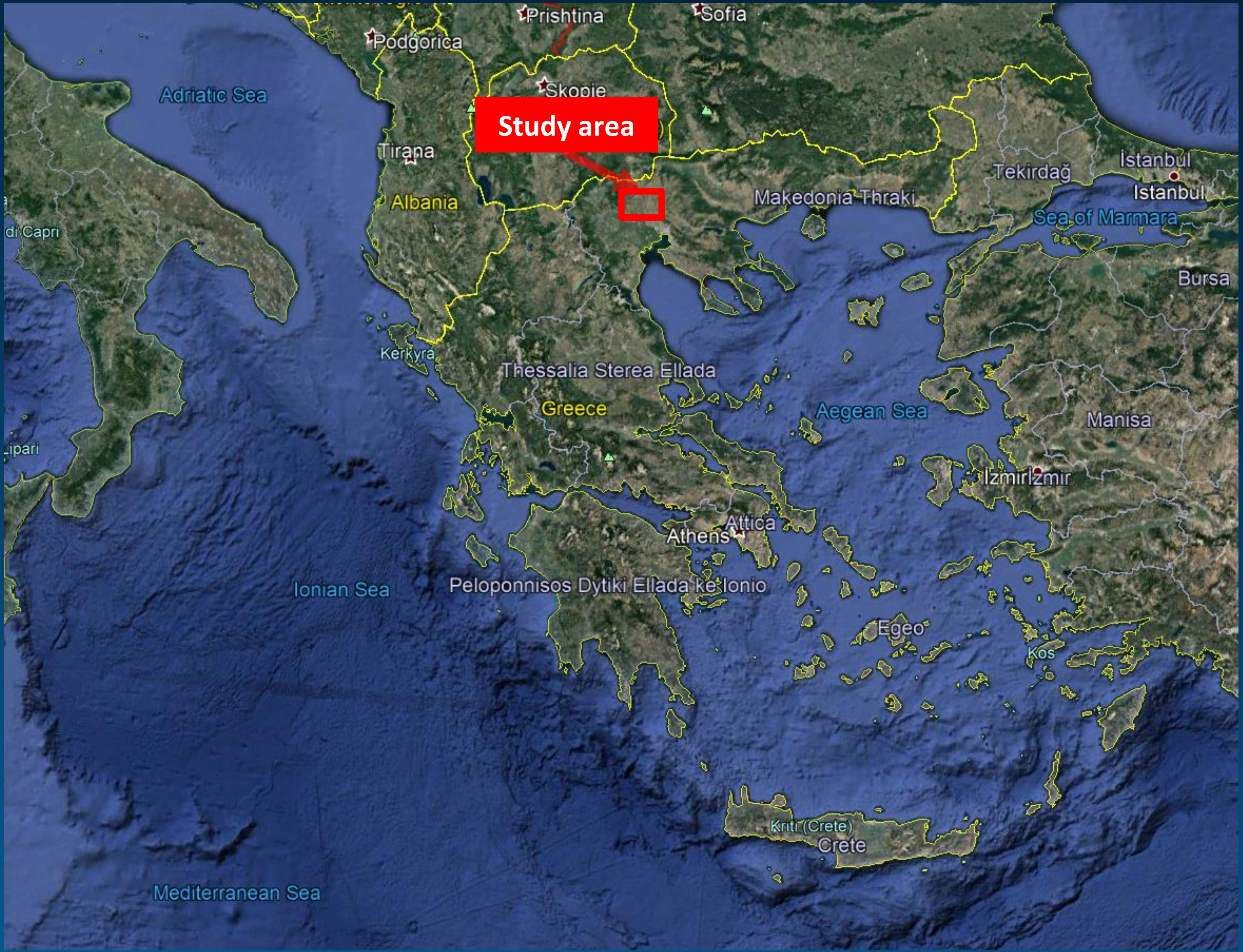
OBJECTIVES

Development of a methodology for evaluating the effect of soil quality on vines and delineation of management zones based on soil conditions.

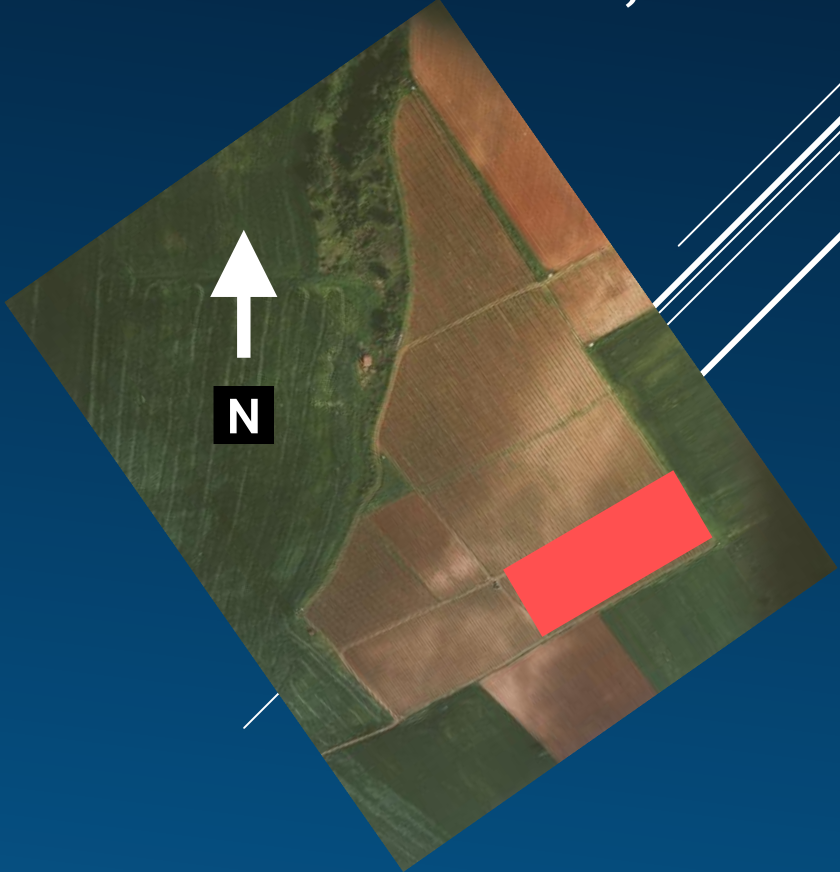
Specific objectives where:

- Determination of a minimum Data Set
- Deliniation of the vineyard in site specific management zones
- Assessment of soil soil quality taking into account the effective soil depth

MATERIALS AND METHODS



- Experimental vineyard of Boutaris S.A. in Goumenisa, Northern Greece.
- Area selected was 0,8 ha



EXPERIMENTAL VINEYARD

- 35 plots were selected
- each one including 24 vines
- 3 rows of 8 vines
- Uniform slope (171-191m) facing east
- Variety of "xynomavro"
- Drip irrigation
- Small size and uniform conditions to exclude other factors of "terroir" except soil conditions

SOIL DATA

- Soil sampling from 35 plots plus four trenches for studying rootzone
- Soil boreholes up to 1.5m and sampling according to soil layers
- 22 soil properties were measured
- Sand, Silt, Clay, Carbonates, Active Calcium Carb., OM, FC, pH, EC, Ca, Mg, Na, K, P, TN, Cu, Zn, Fe, Mn, BD, WFPS, Cmic.

SOIL DATA

- Soil penetration resistance in 35 plots
- Four soil trenches were excavated for determining rootzone depth
- Thus verifying that penetration resistance of 2MPa is the limit for root expansion

GRAPE DATA

- 400 grapes were collected from each plot
- Six parameters were measured
- Brix, Total acidity, pH, weight, phenol index, total anthocyans

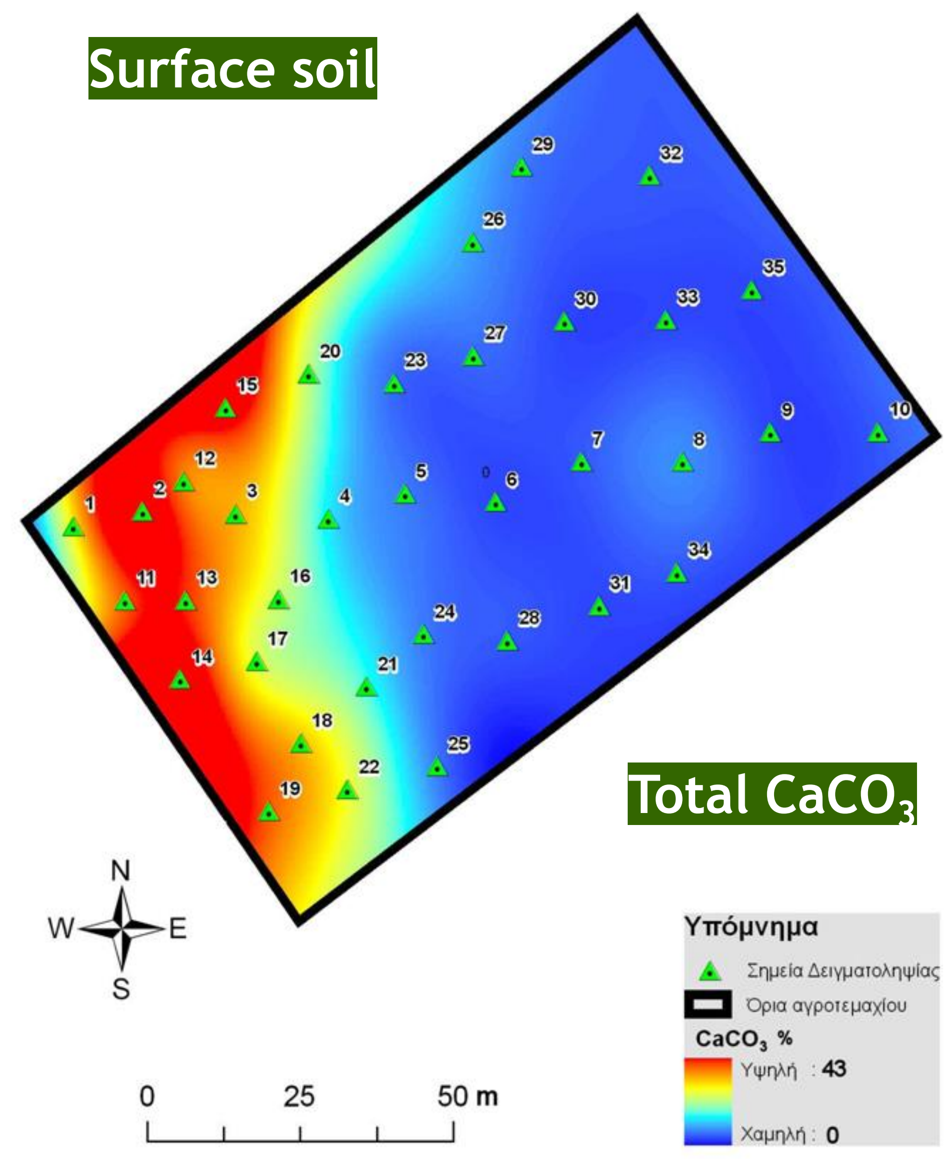
WINE DATA

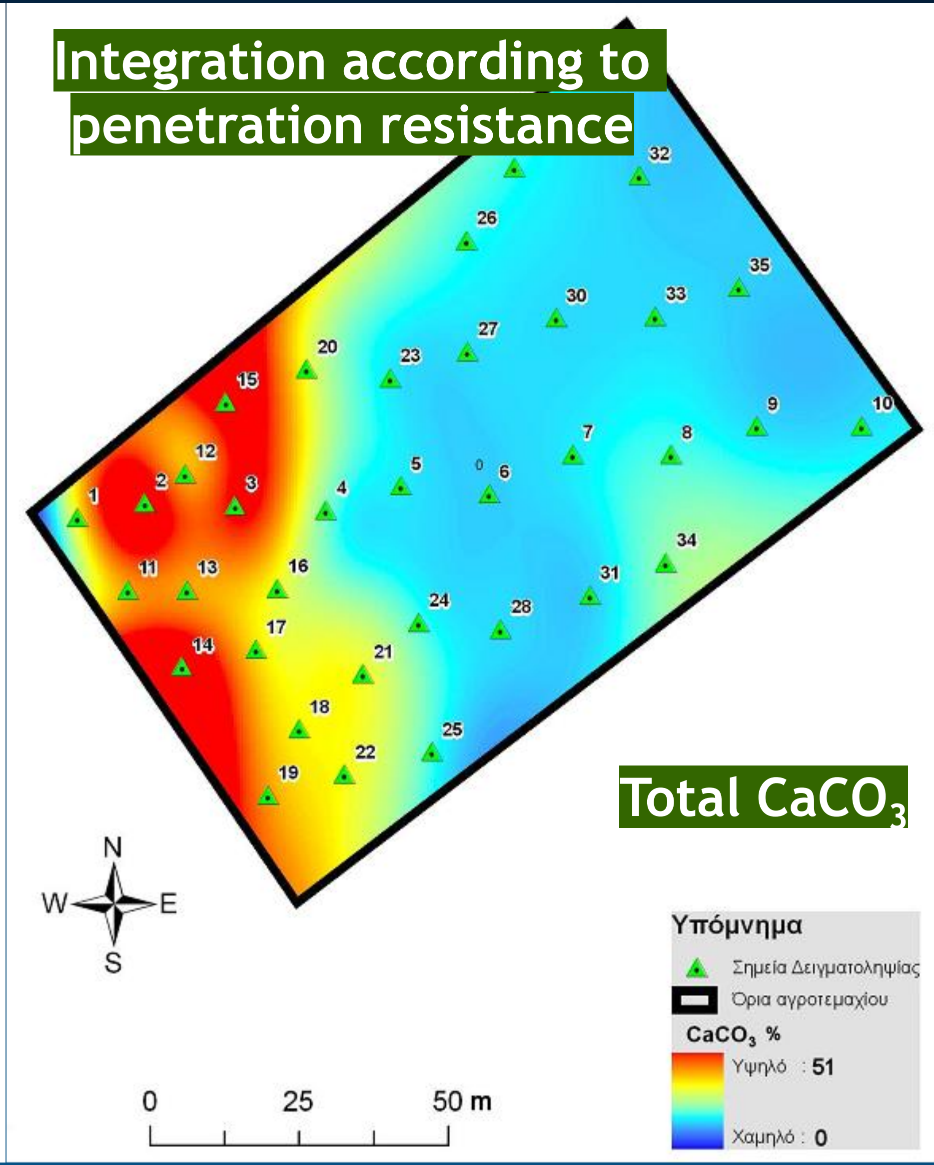
- After harvest 15Kg of grapes from each were process for wine production in 30L tanks
- The procedure was uniform for all plots
- 18 parameters were measured
- Alcohol, sugar, specific weight, color, acidity, total anthocyans, lactic acid, etc.

METHOD

- For soil quality assessment four soil depths were used for integrating soil properties
- Surface soil, soil depth up to parent material, soil depth where penetration resistance was below 2Mpa, and integration of soil properties up to the depth designated by Principal Component Analysis.
- Principal Component Analysis was used for data reduction, thus selecting the Minimum Data Set for soil, grapes, and wine.
- Canonical Correlation was employed for examining the relation among soil and grapes or wine.

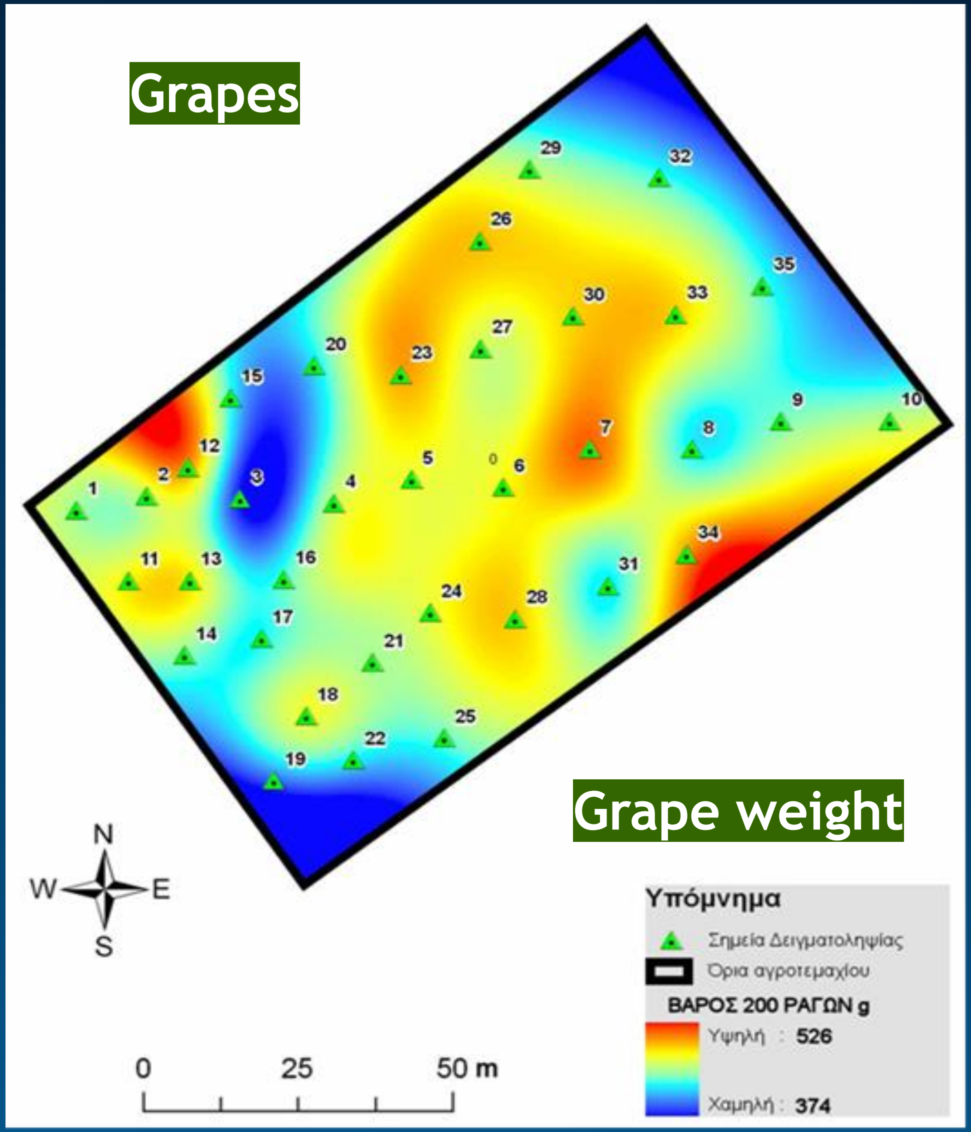
RESULTS AND DISCUSSION
SOIL

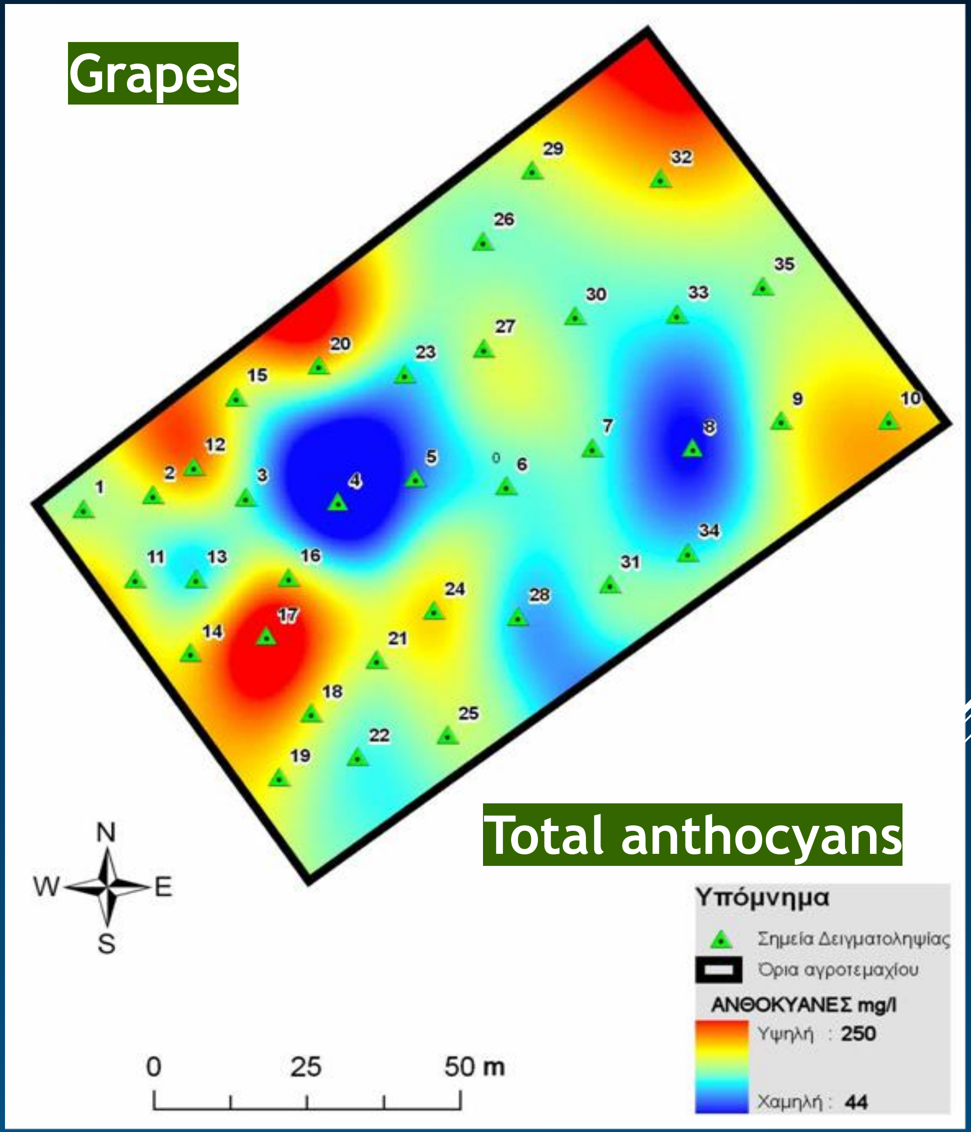




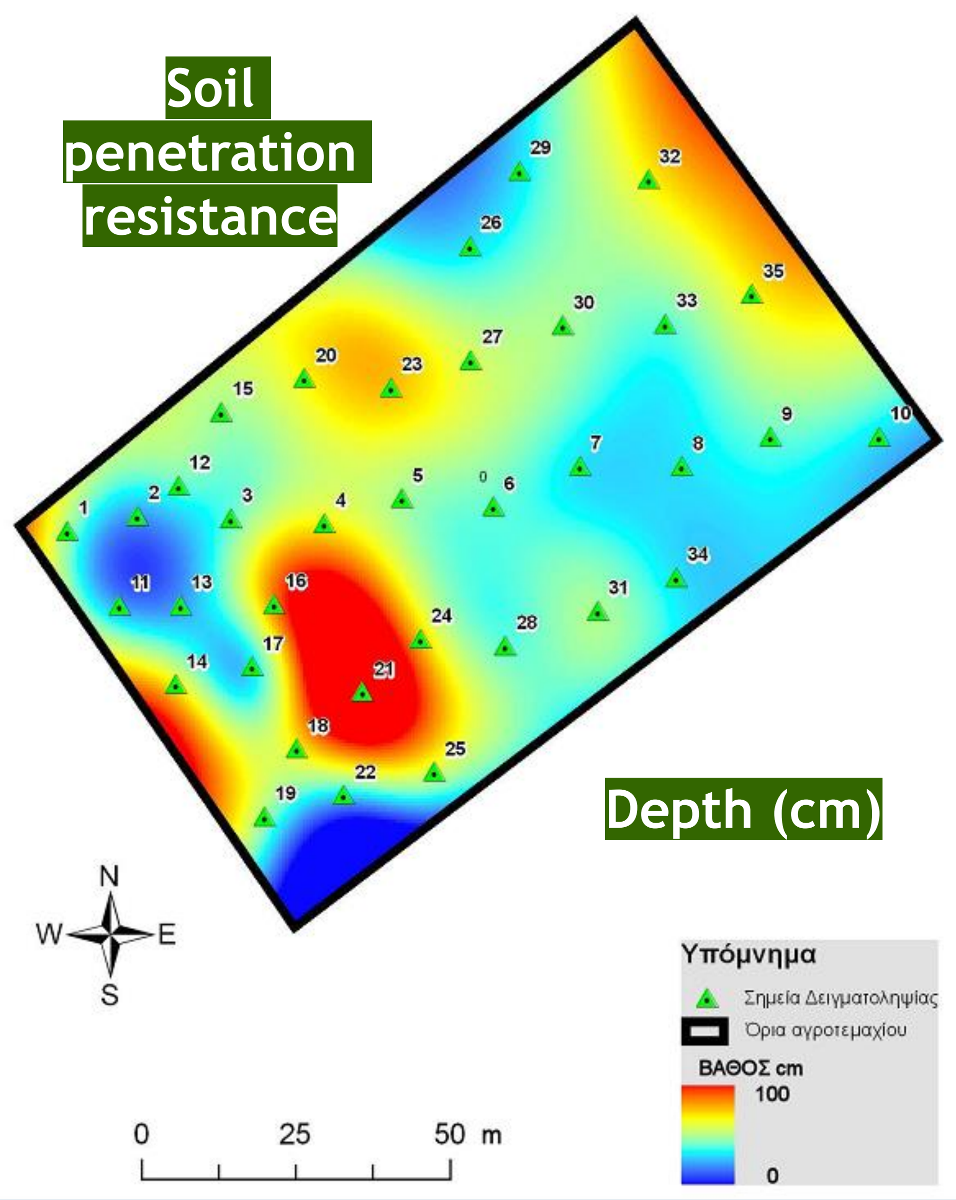
- More than 120 interpolation maps were created for soil, grape, and wine properties

GRAPES AND WINE





PENETRATION RESISTANCE



- Soil penetration resistance ranged from 35 to 70 cm from soil surface.
- Shallow soil depth in some plots was expected as a petrocalcic horizon formed an impermeable layer
- Red color is deep soil
- Blue color is shallow soil

ROOT ZONE

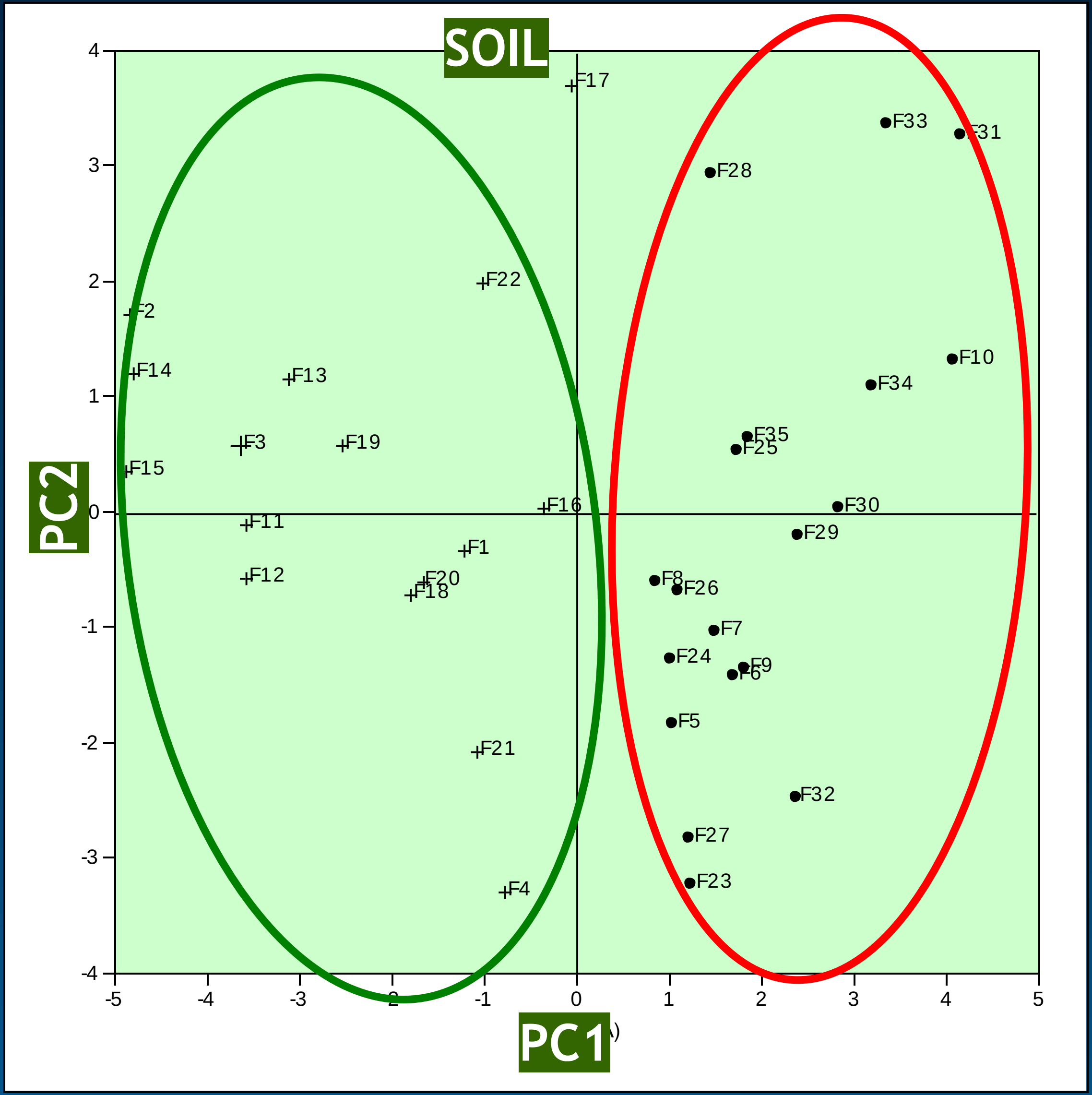
- Rootzone study showed that measurements of penetration resistance are representative of rootzone depth.
- Soil penetration resistance can be used for estimating the potential effective soil depth.
- Very useful information prior to establishing a vineyard

PRINCIPAL COMPONENT ANALYSIS

MINIMUM DATA SETS		
Soil	**Gapes**	**Wine**
Total $CaCO_3$	Brix	Sugars
OC	Total acidity	Total acidity
Ca	Weight	Total anthocyans
Na	Total anthocyans	Tartaric acid
K		K
Total N		Na
Zn		Mg
Cmic		

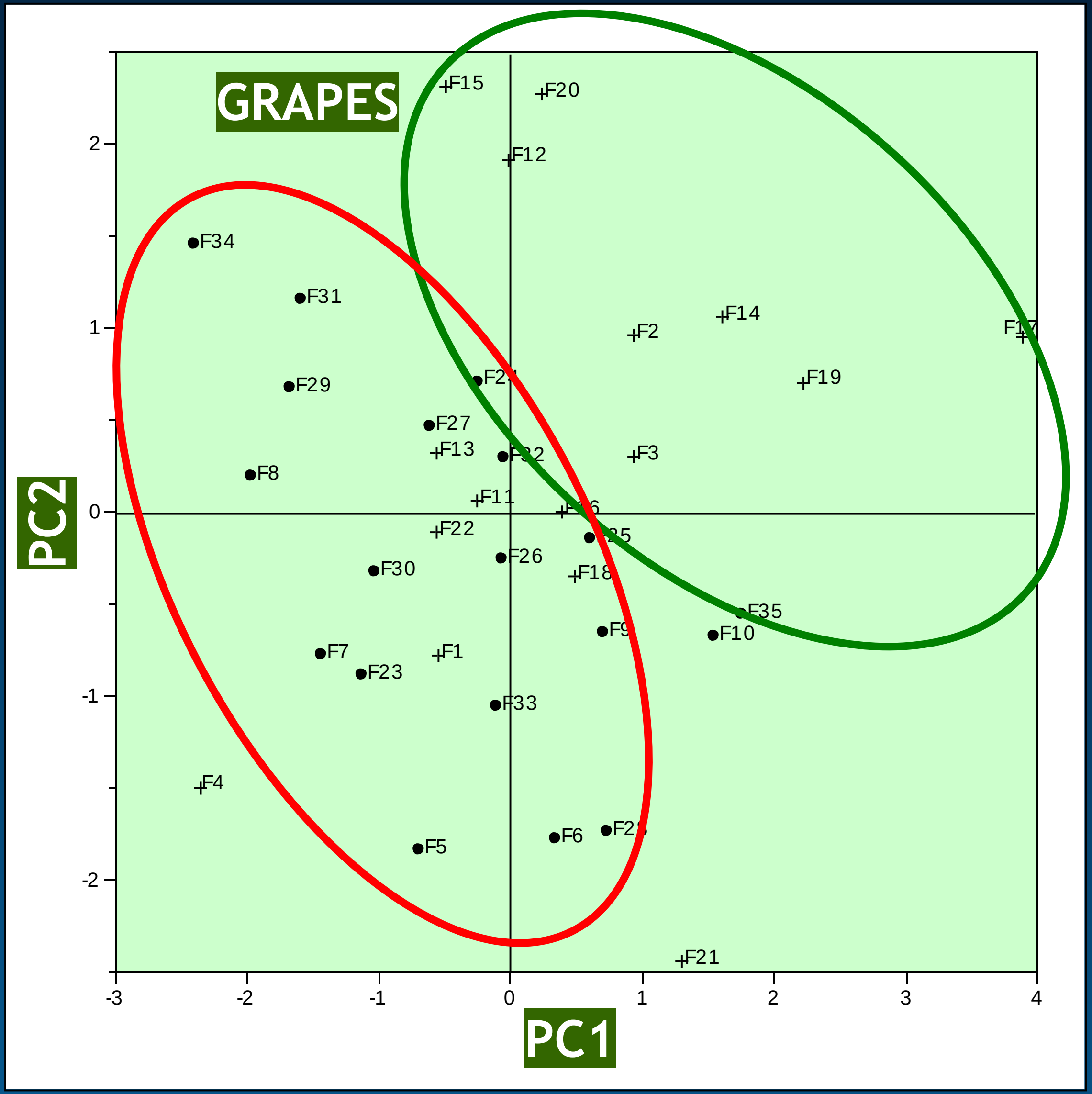
- Properties selected through PCA were the one with the highest values in the Principal components.
- Properties that were correlated with other that had high values in the Principal components were rejected.
- Avoid autocorellation

PRINCIPAL COMPONENT ANALYSIS



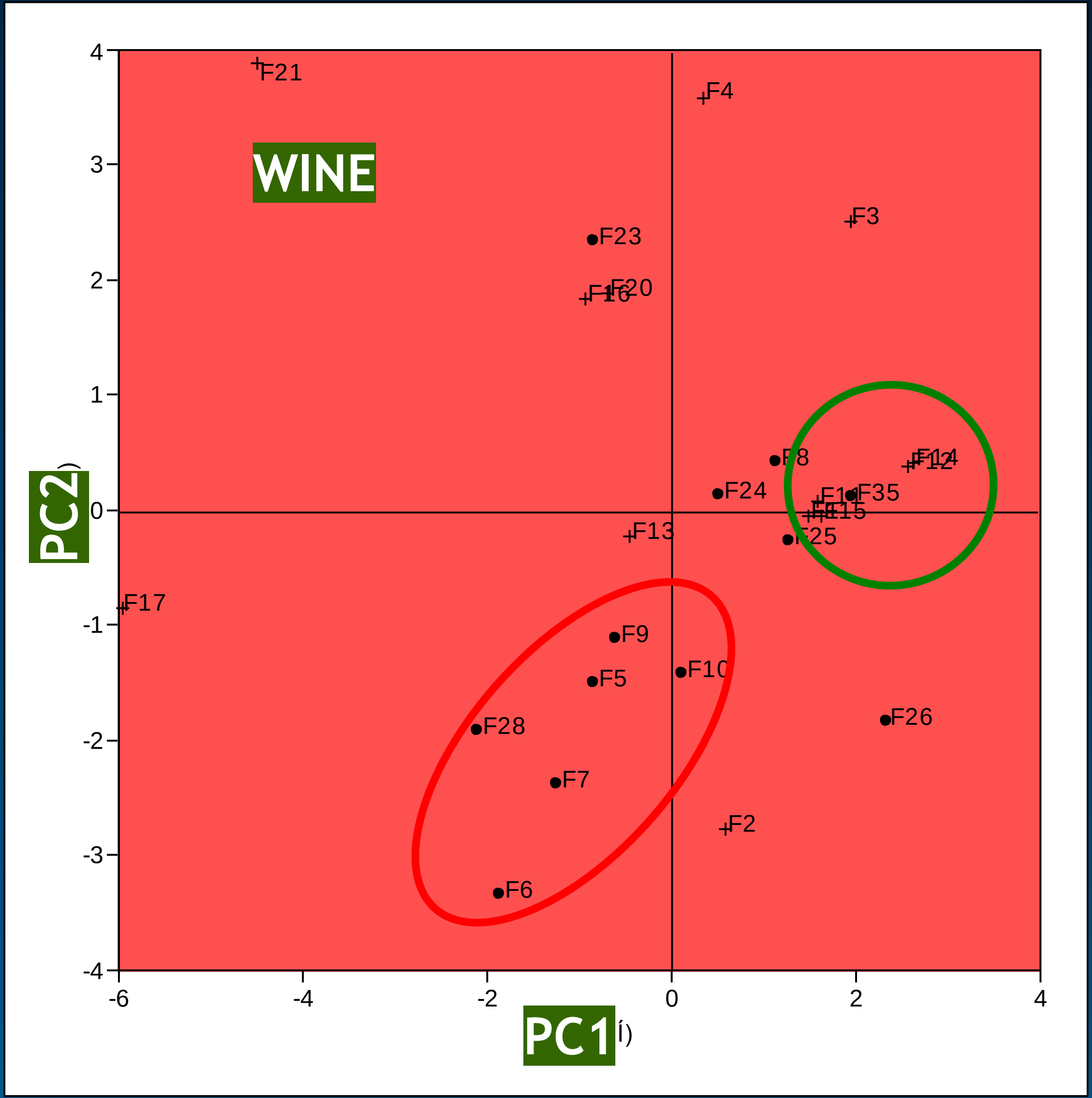
- First two Principal Components grouped soil properties in two distinctive areas.
- In a small vineyard two management zones are adequate for implementing agricultural practices.

PRINCIPAL COMPONENT ANALYSIS



- First two Principal Components of grapes grouped plots in two areas.
- However several plots were out of limits, probably from variable pruning practices.c

PRINCIPAL COMPONENT ANALYSIS



- In case of wine, grouping was not effective.
- Several plots were out of limits, probably from variable agricultural practices, that affected grapes and consequently wine.
- Think that vinification is heavily affecting grape properties (complete transformation) and it is difficult to achieve uniform conditions.

CONCLUSIONS

- The method developed can encompass and manage a large dataset for evaluating soil quality.
- Site specific management zones based on soil quality can be delineated through the procedure, and these zones are reflected to crop quality and quantity.
- Effective soil depth is essential when assessing soil quality in vineyards, and potentially for deep rooting plants.
- The method can be applied in other crops or geographical areas.

MAPPING OF SOIL QUALITY

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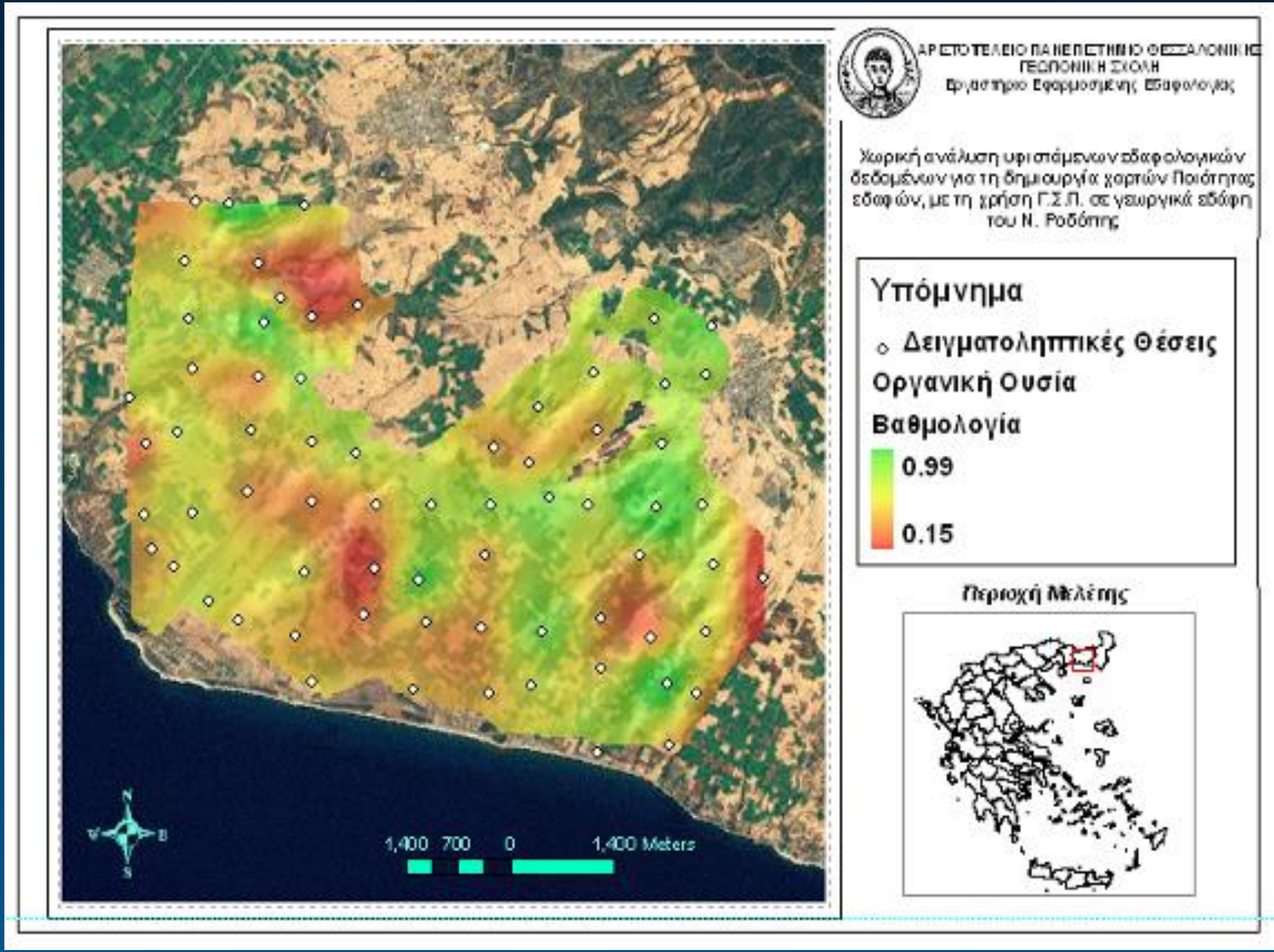
MAPPING OF SOIL QUALITY

- Case study of Rodopi
- Northern part of Greece
- Greek soil database

MAPPING OF SOIL QUALITY

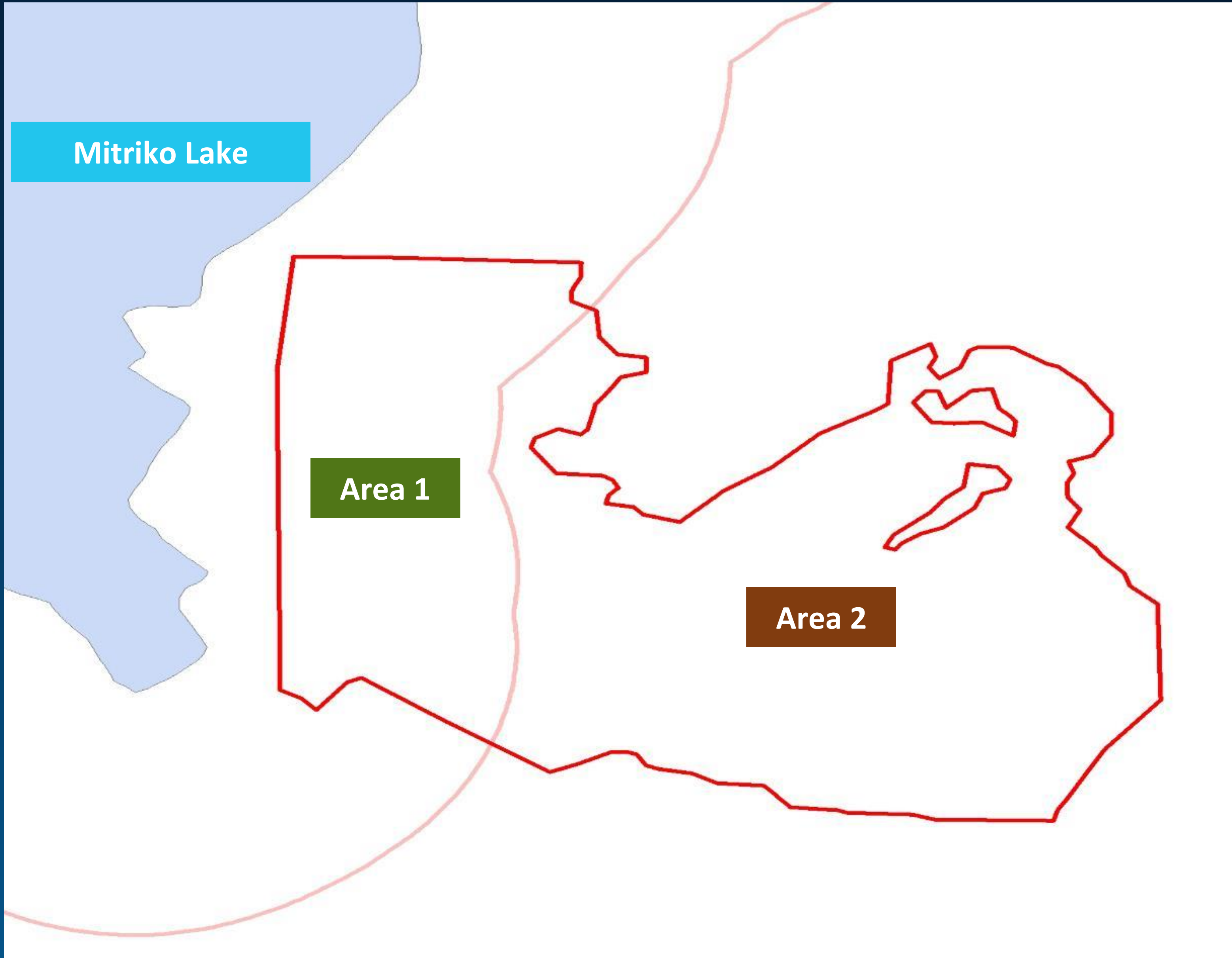
- Agricultural land
- Adjacent to Natura 2000 protected area

MAPPING OF SOIL QUALITY



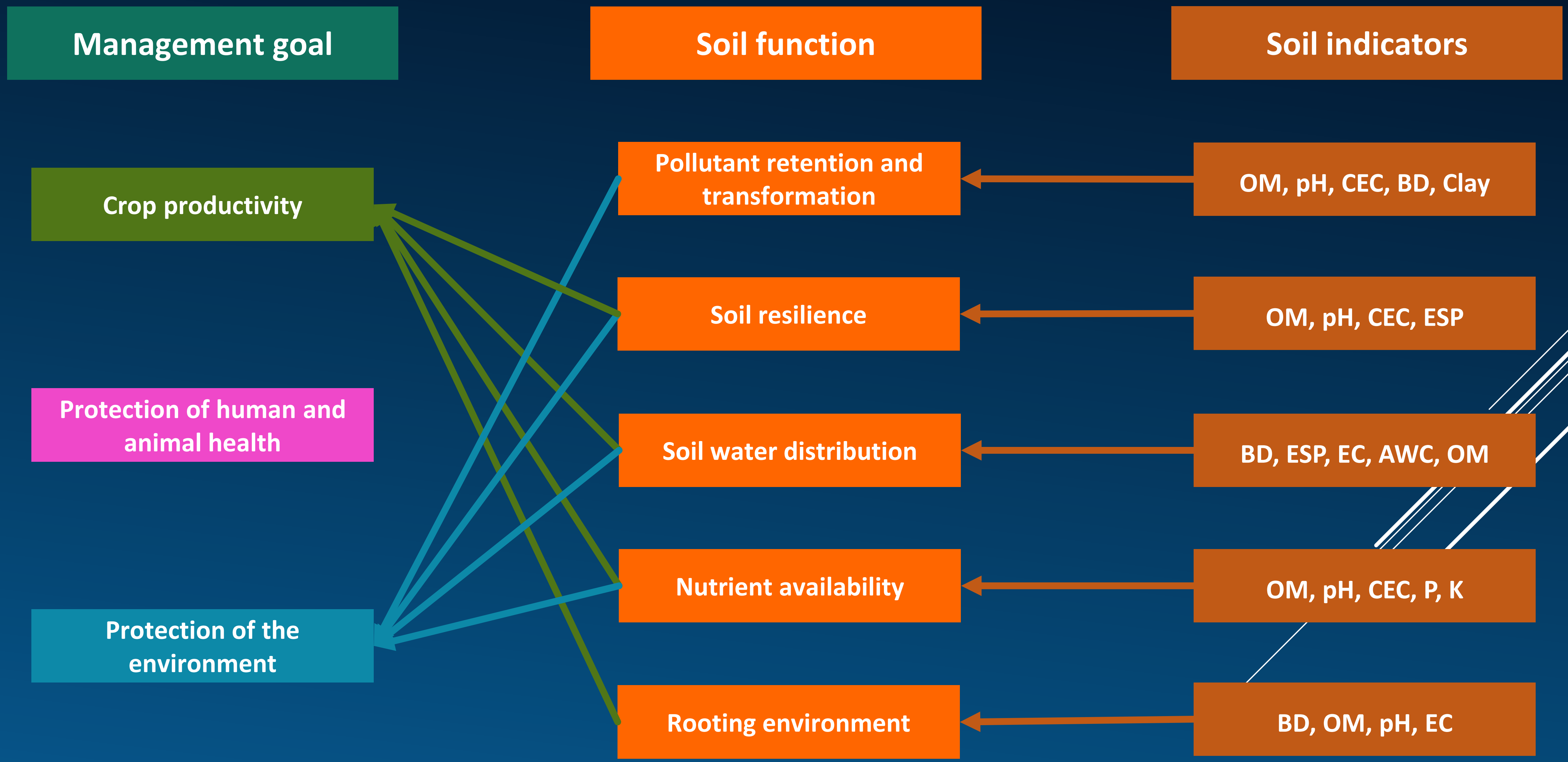
- 4,000 ha
- Greek soil data base
- Data from 69 soil profiles
- Surface soil properties
- Main crops
- Cotton and wheat

MAPPING OF SOIL QUALITY



- Agricultural land
- Adjacent to Natura 2000 protected area
- Buffer zone of 3,000m
- Area 1: Protection of the environment
- Area 2: Crop production

MAPPING OF SOIL QUALITY



MAPPING OF SOIL QUALITY

Pollutant retention and transformation (PRT) = OM x w_1 + pH x w_2 + CEC x w_3 + BD x w_4 + Clay x w_5

Soil resilience (SR) = OM x w_1 + pH x w_2 + CEC x w_3 + ESP x w_4

Soil water distribution (SWD) = BD x w_1 + ESP x w_2 + EC x w_3 + AWC x w_4 + OM x w_5

Nutrient availability (NA) = OM x w_1 + pH x w_2 + CEC x w_3 + P x w_4 + K x w_5

Rooting Environment (RE) = BD x w_1 + OM x w_2 + pH x w_3 + EC x w_4

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

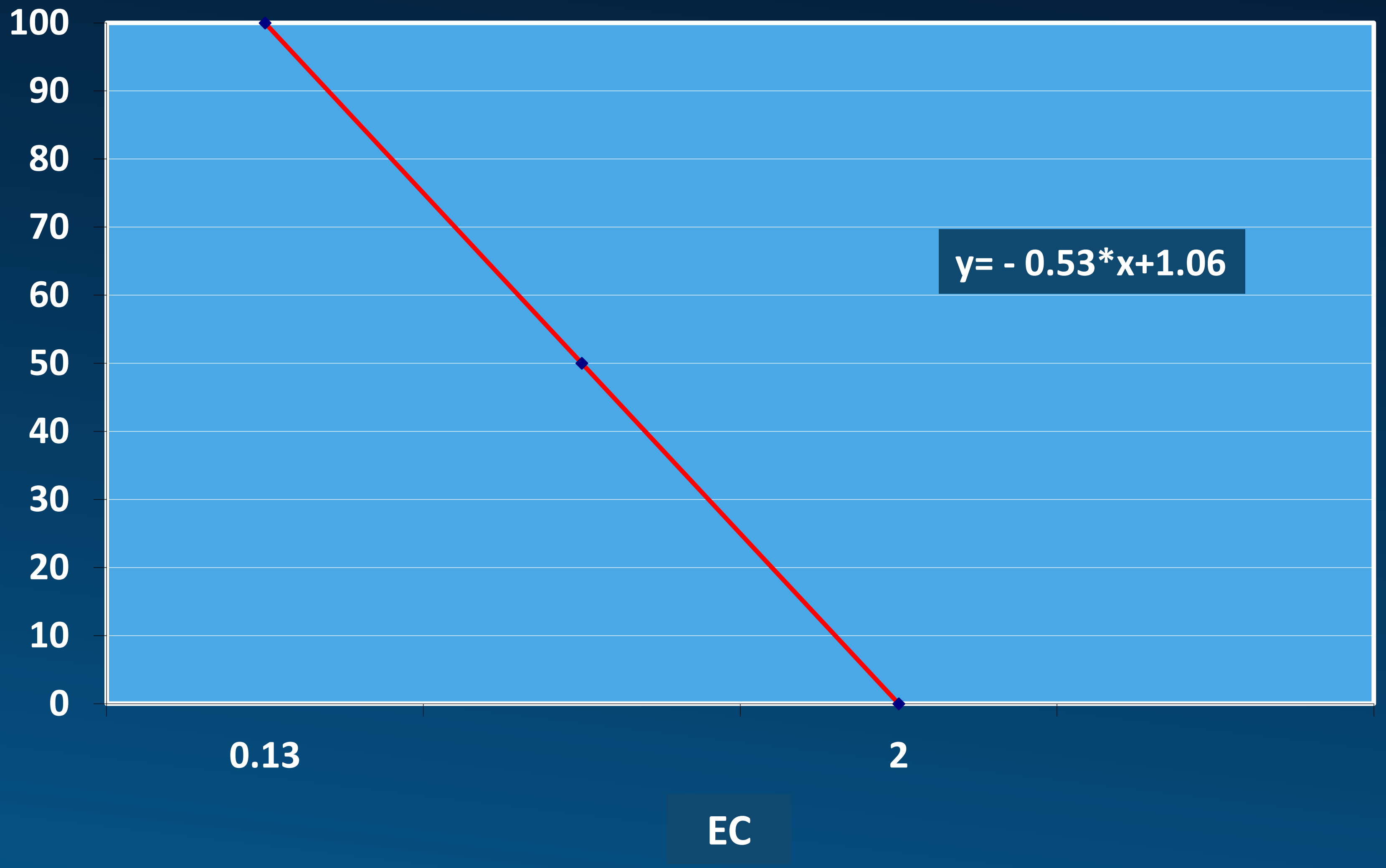
- Calculation of Soil Quality Index (SQI)
- Assign soil indicators to each soil function that best represent the performance of the function

MAPPING OF SOIL QUALITY

Indicator	Lower threshold	Optimum	Upper threshold
pH	5,5	7,5	8,5
OM (%)	0	2,62	-
CEC	0	45,6	-
EC (dS/m)	-	0,13	2
ESP	-	1,38	15
BD (g/cm3)	-	1,29	2
P (ppm)	0	168	-
K (ppm)	0	350	500
AWC (%)	0	15,7	-
Clay (%)	0	54,7	-

- After soil indicators assigned to soil functions
- Scoring of soil indicators
- Standardization of soil properties values
- Threshold values of soil indicators

MAPPING OF SOIL QUALITY

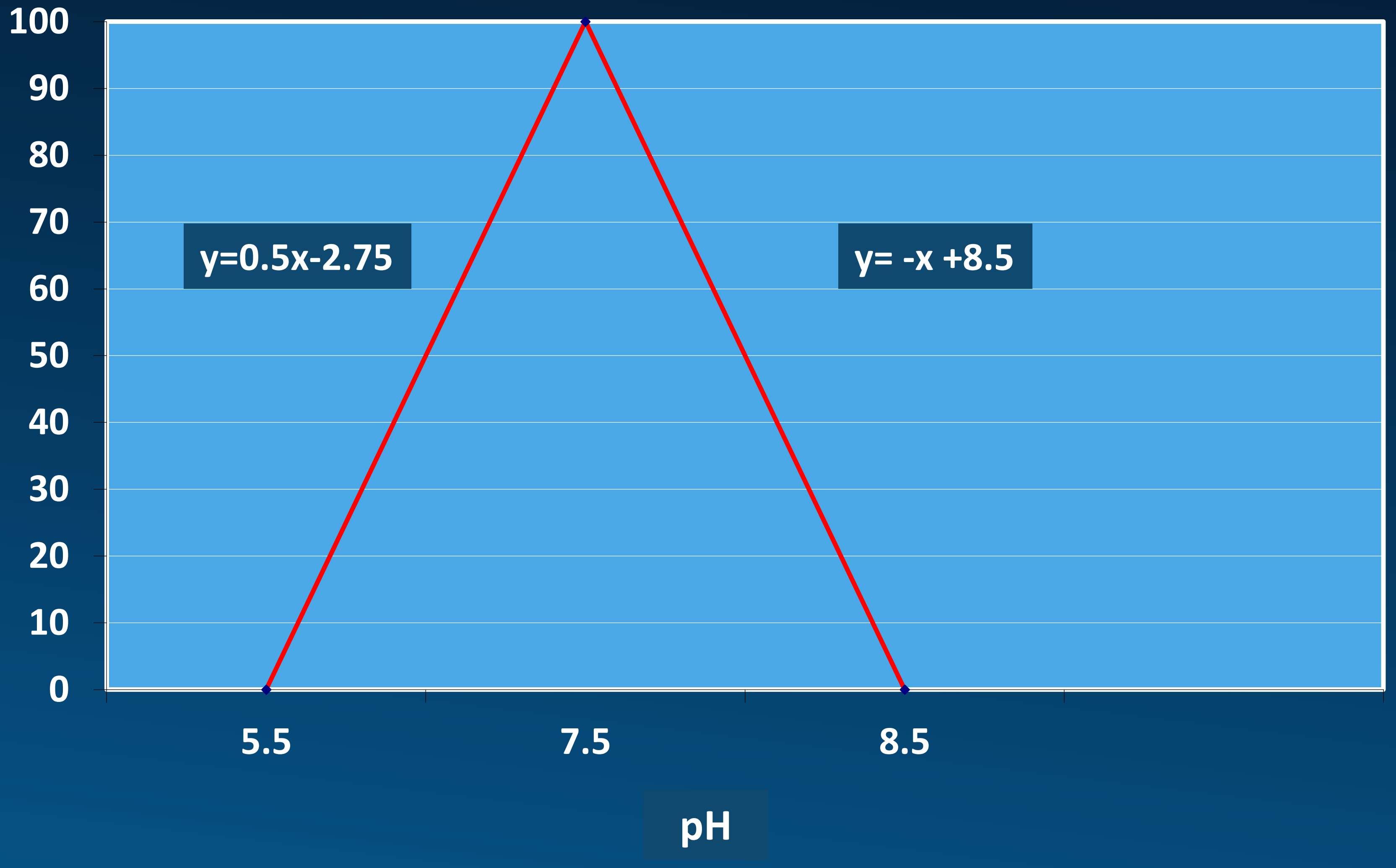


- Soil indicator score
- EC
- Optimum value
- Upper threshold

MAPPING OF SOIL QUALITY

- Soil indicator score
- EC
- Optimum value
- Upper threshold

MAPPING OF SOIL QUALITY



- Soil indicator score
- pH
- Optimum value
- Upper threshold
- Lower threshold

MAPPING OF SOIL QUALITY

Value	Significance
1	equal
3	moderate
5	strong
7	very strong
9	extreme
2,4,6,8	Intermediate values

Criteria	C1	C2	C3
C1	1	5	4
C2	0.2	1	2
C3	0.25	0.5	1

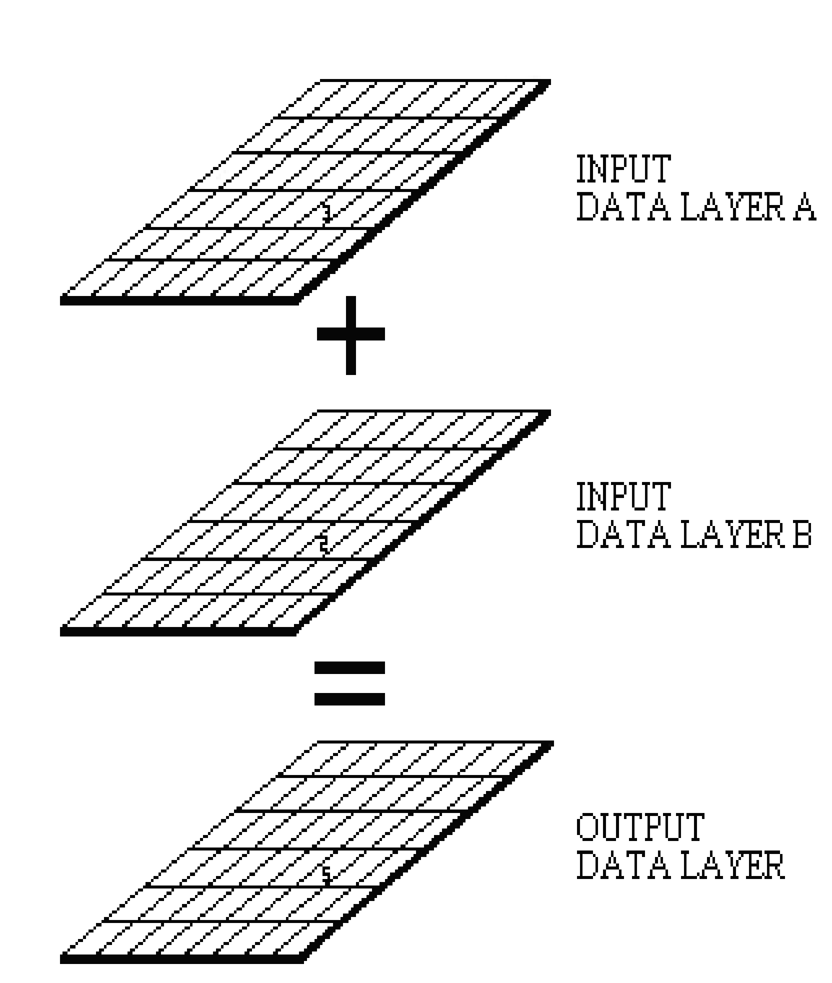
- Weighing factors
- W for soil functions
- w for soil indicators
- AHP
- Analytical Hierarchy Process
- Multicriteria decision support method
- Thomas Saaty

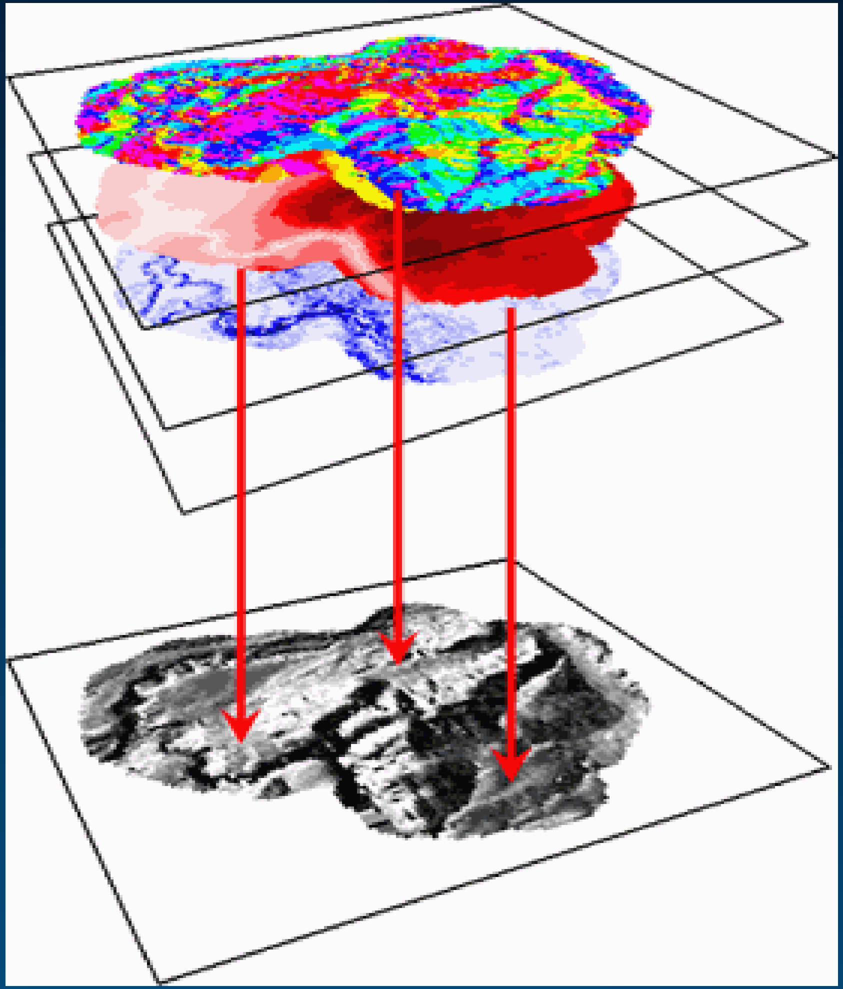
MAPPING OF SOIL QUALITY

	Protection of the environment	Crop productivity
Soil function	Weighing factor	Weighing factor
Pollutant retention and transformation	0,46	-
Rooting environment	-	0,14
Soil resilience	0,28	0,27
Soil water distribution	0,16	0,17
Nutrient availability	0,1	0,42

- Weighing factors of soil functions for each management goal

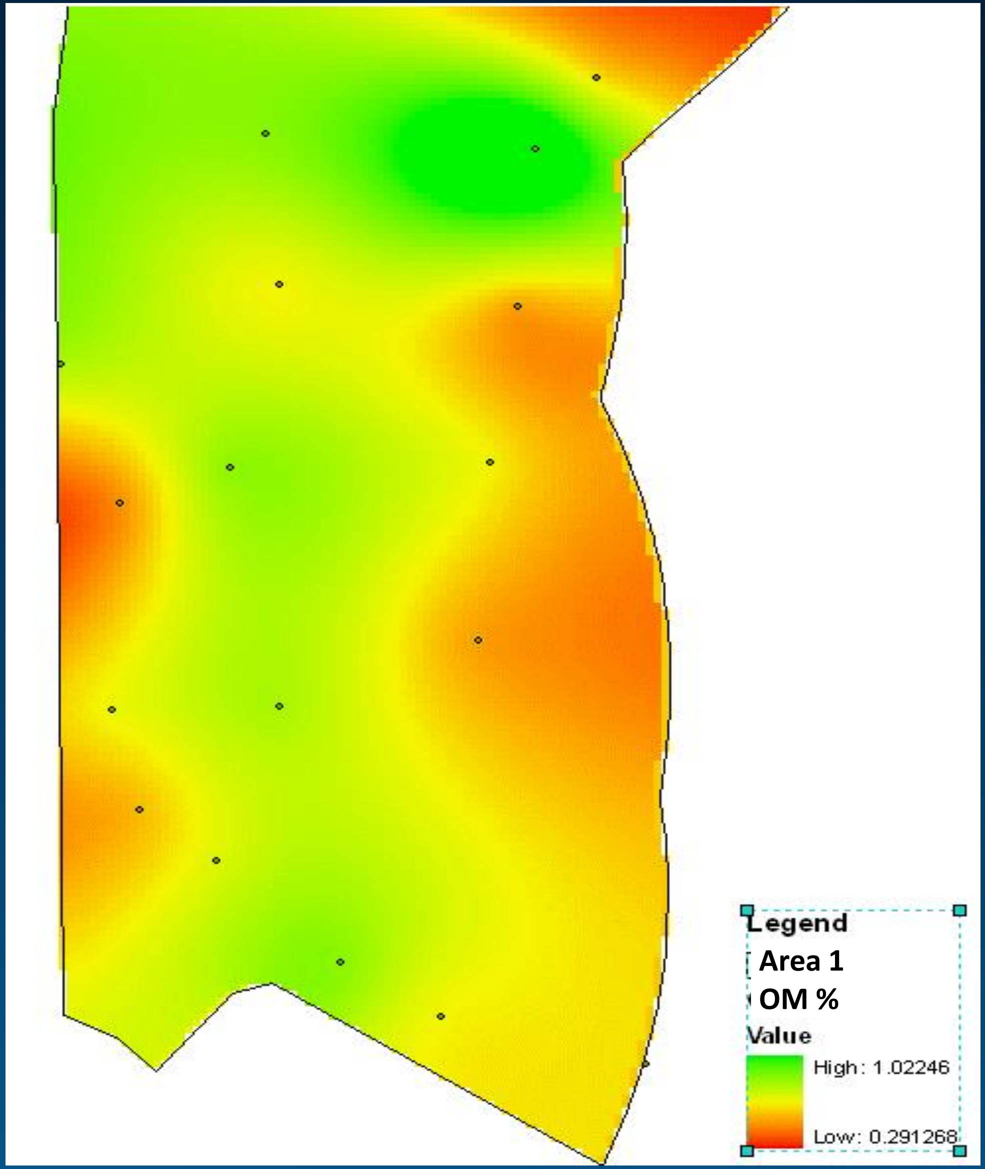
MAPPING OF SOIL QUALITY

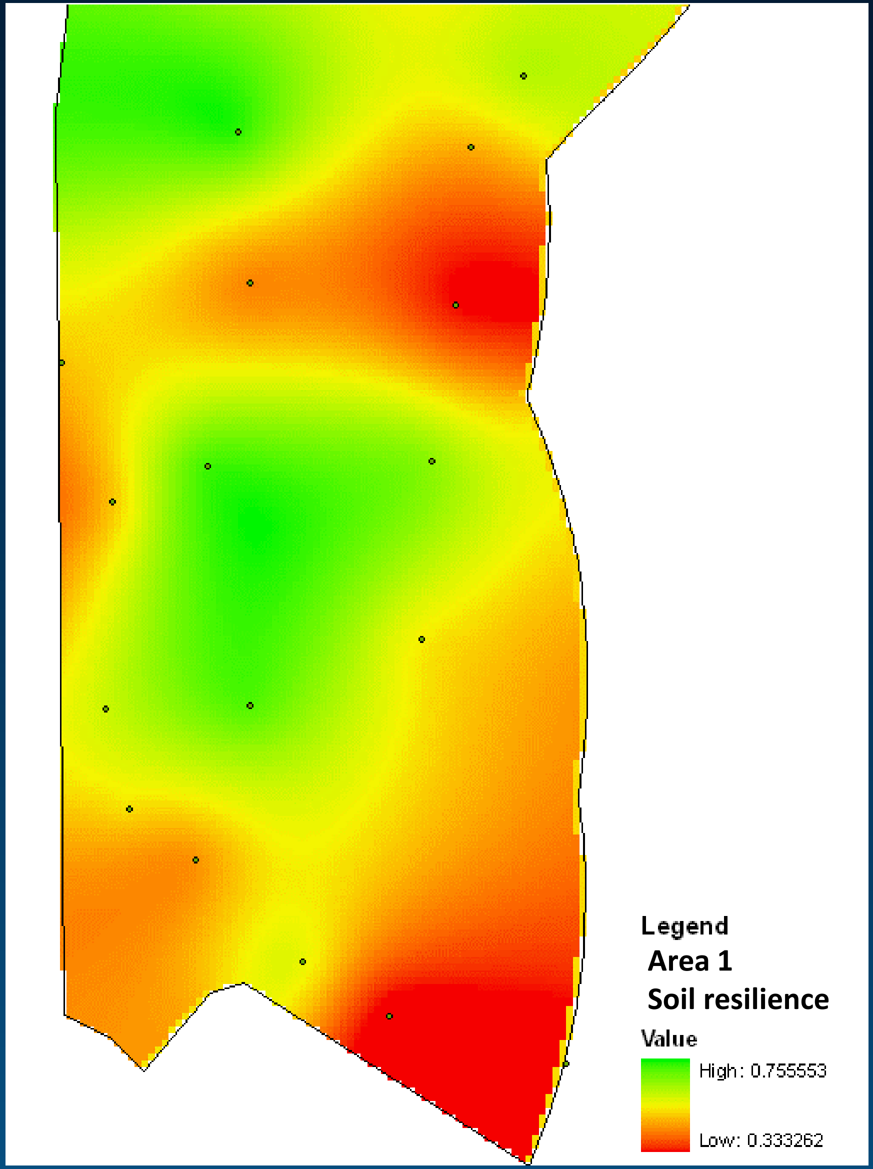




- For creating map of soil quality
- Combine score layers according to equations formed from the above stages
- First combine layers of soil indicator scores for calculating soil functions performance
- Second combine soil function scores for calculating Soil Quality Index

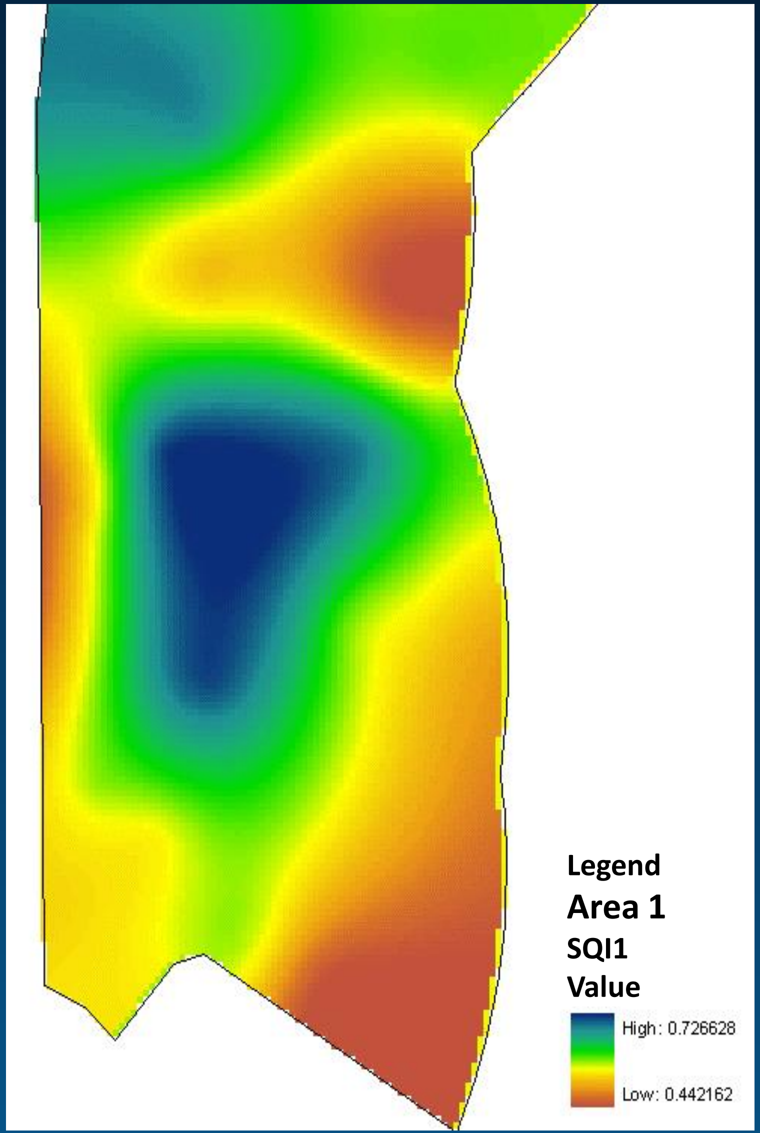
MAPPING OF SOIL QUALITY

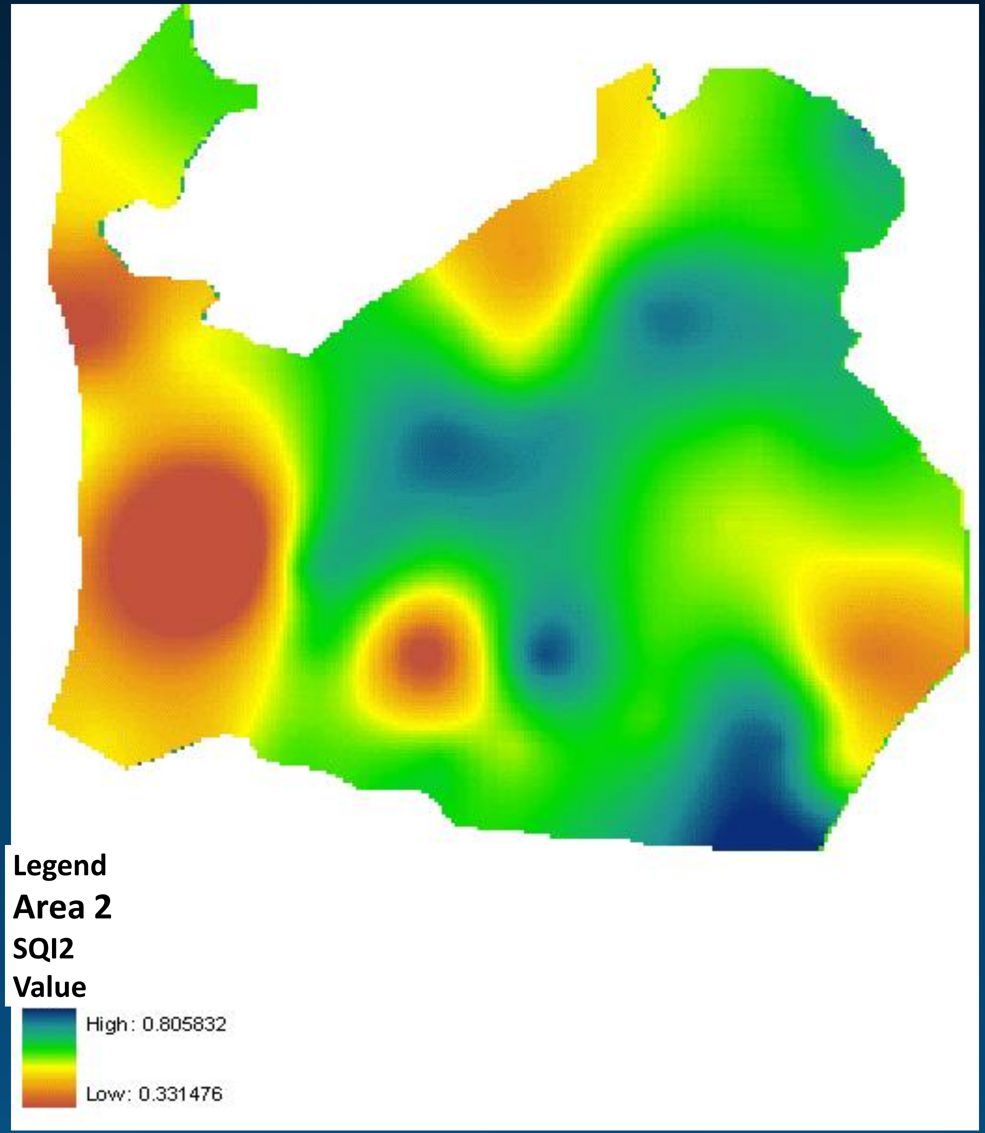




- First step create interpolation maps for each soil indicator
- Used spline interpolation method
- Others where tested
- Combine soil indicators with equations formed
- Create soil functions maps for each area

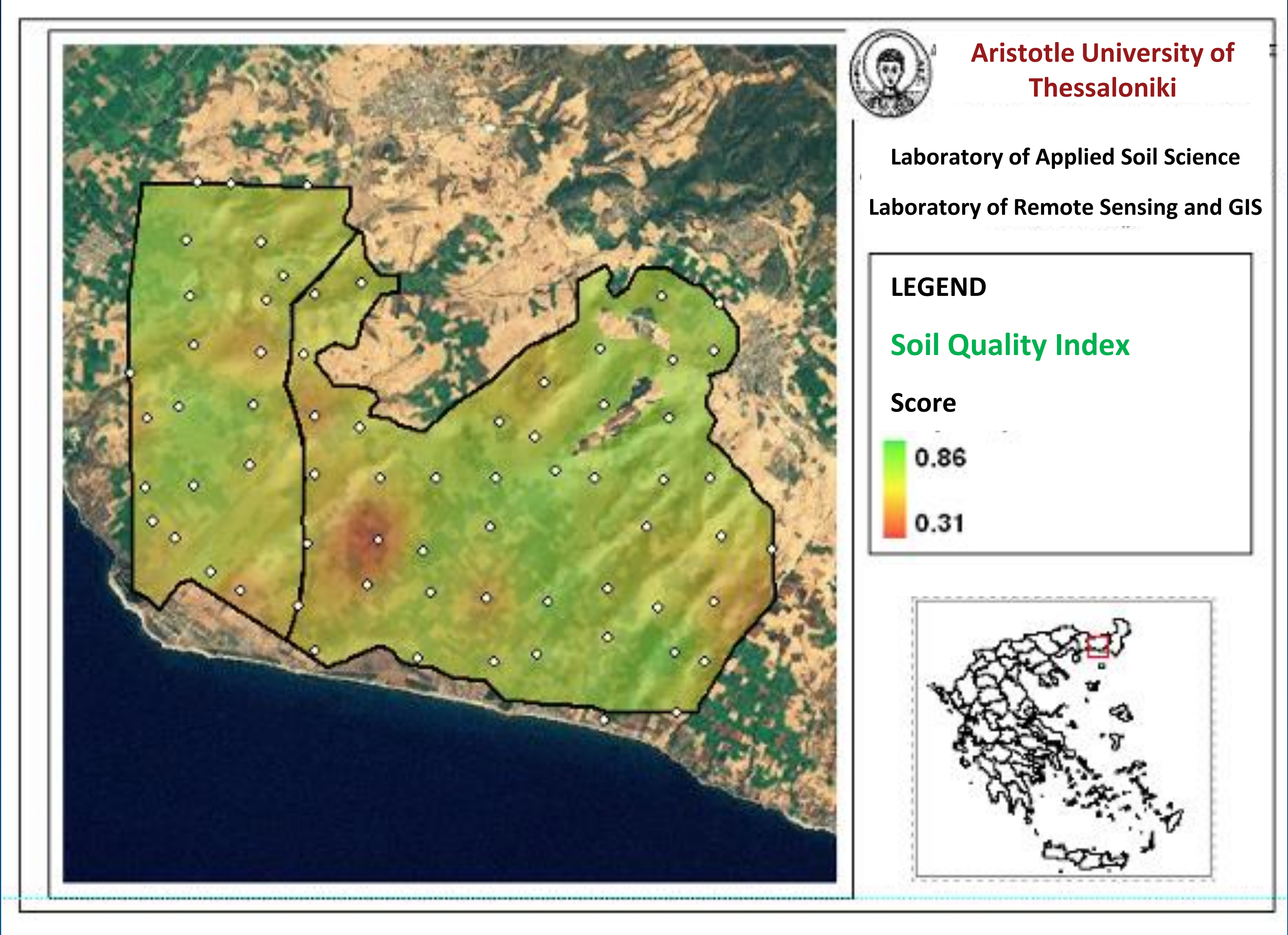
MAPPING OF SOIL QUALITY





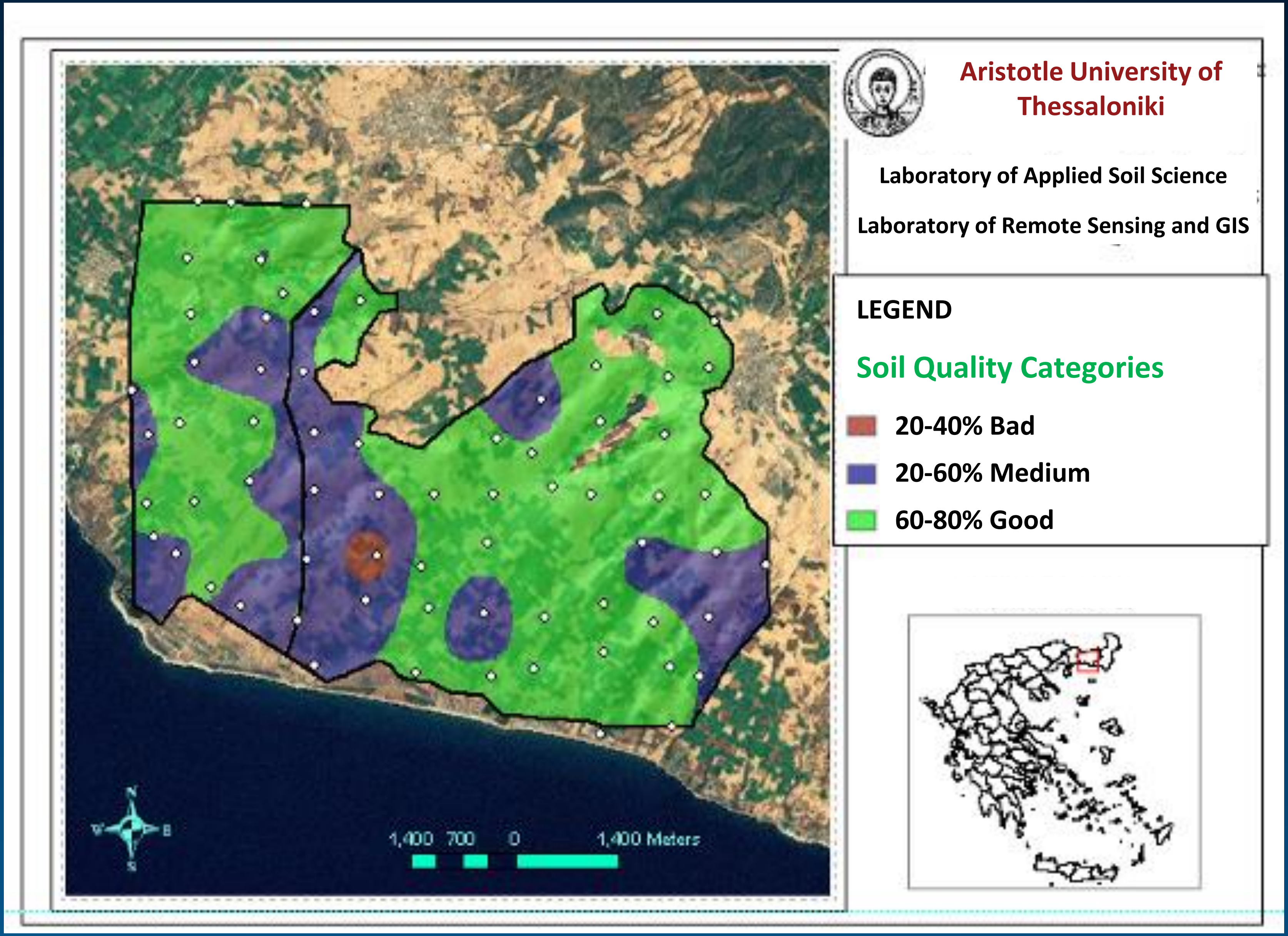
- Final step create soil quality index maps
- Created separately as management goal is different

MAPPING OF SOIL QUALITY



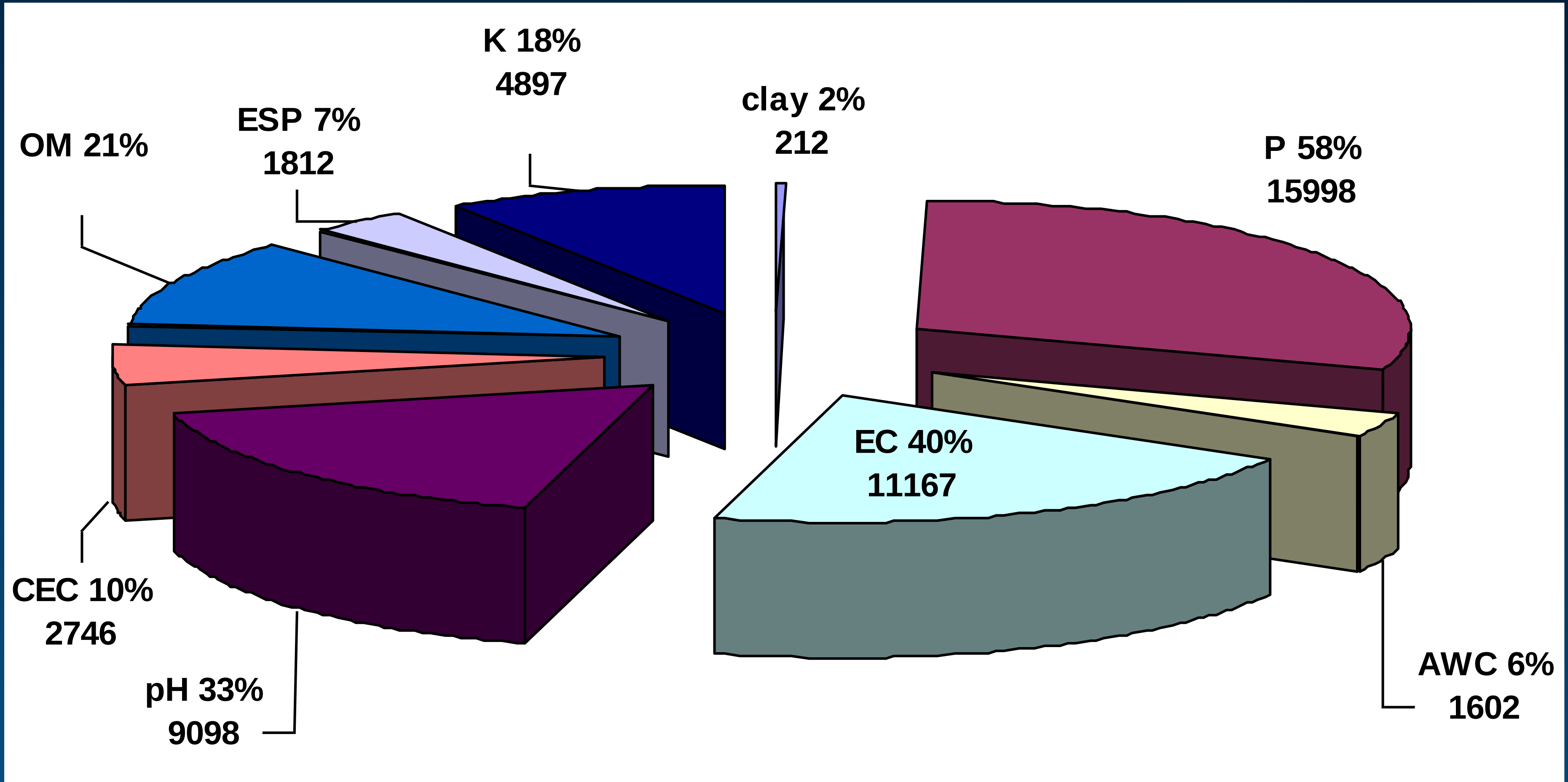
- Results
- Soil Quality Index
- Spatial distribution
- Two areas with different management goal

MAPPING OF SOIL QUALITY



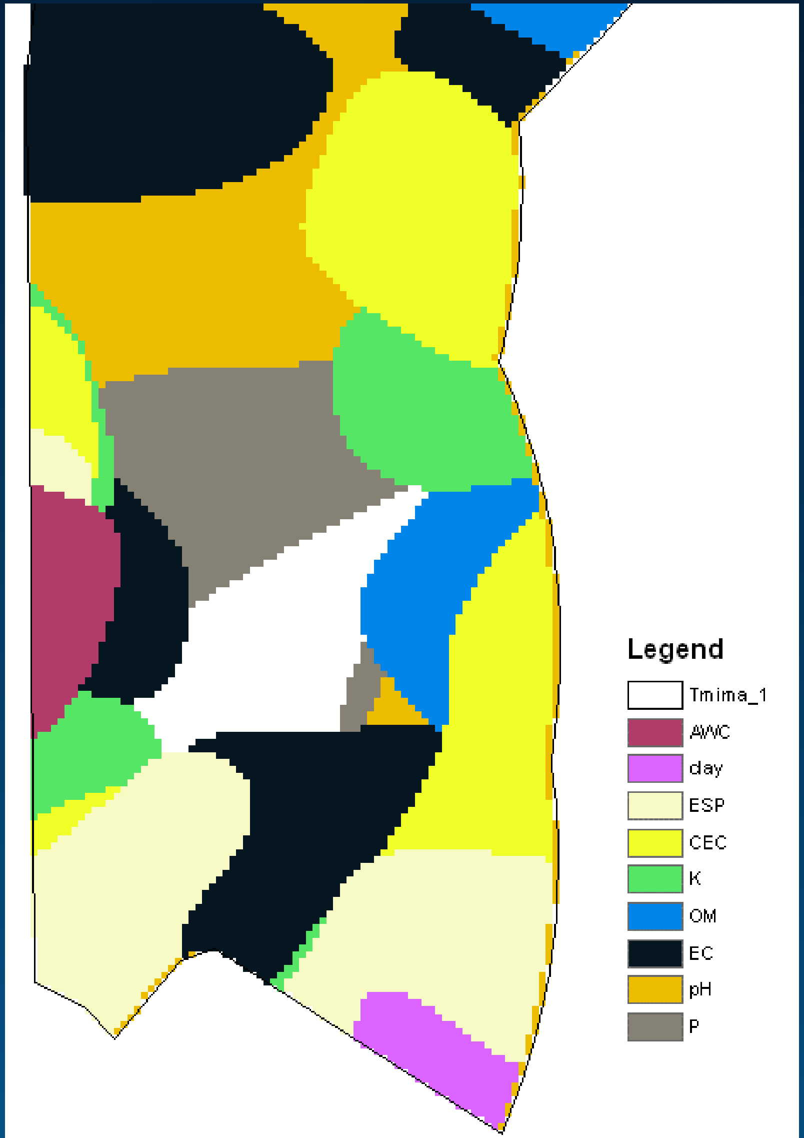
- Other maps – information provided for management practices spatial distribution
- Soil quality categories

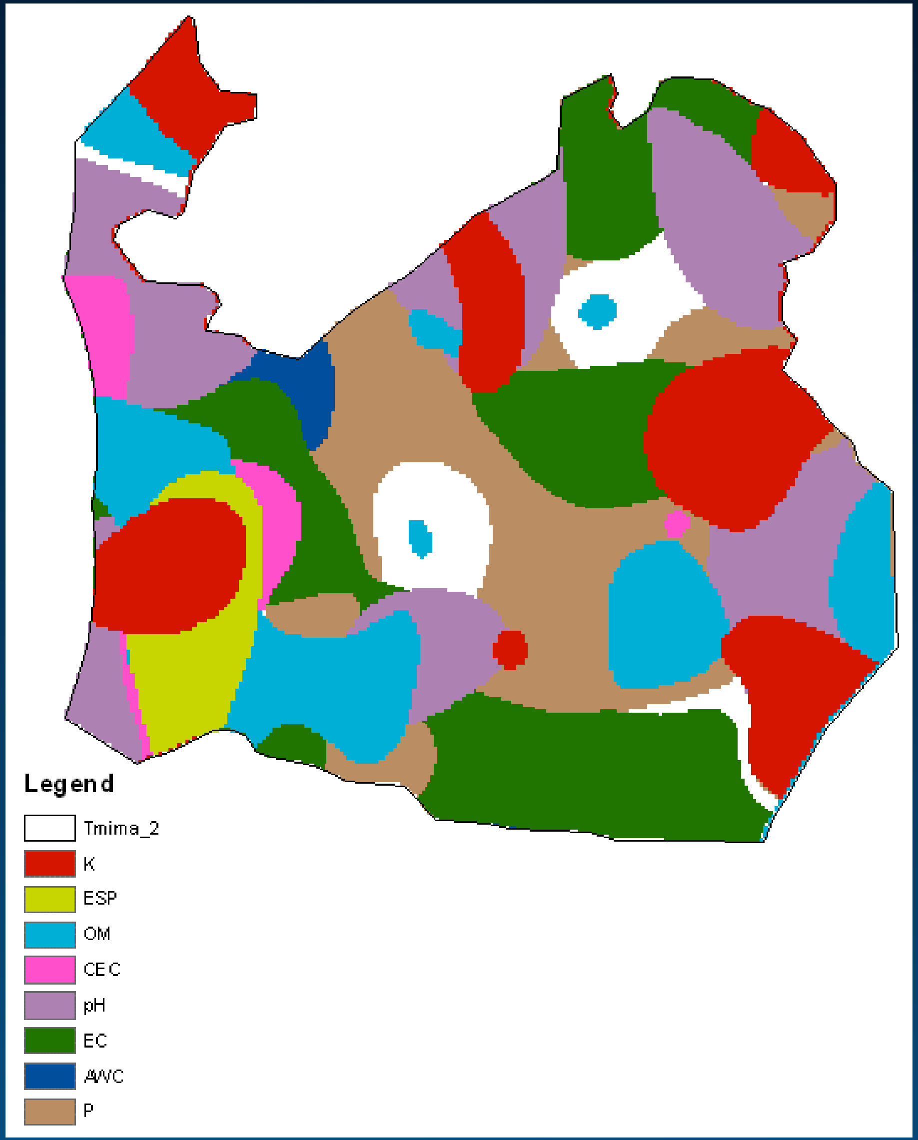
MAPPING OF SOIL QUALITY



- Statistical information
- Determination of main indicator that degrades soil quality
- Area of restrictive soil indicator

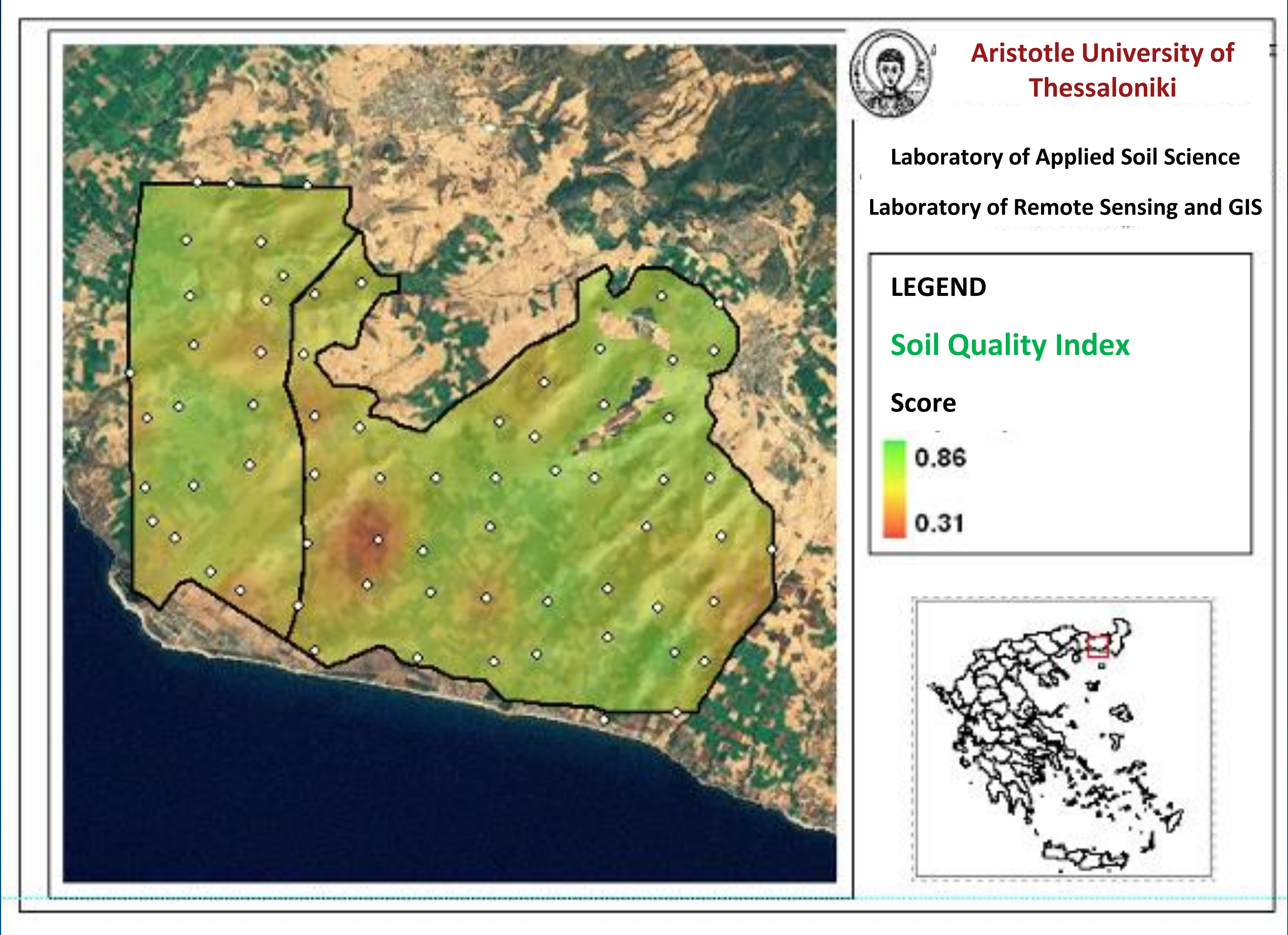
MAPPING OF SOIL QUALITY





- Spatial distribution of indicator that restricts soil quality enhancement
- Necessary for allocating management measures
- Soil restoration methods

MAPPING OF SOIL QUALITY



- Conclusions
- Decision support for agricultural practices
- Crop allocation
- Aim and distribution of subsides