Small, low cost systems for agricultural waste management at field level -the case of pistachio waste at Aegina island, Greece

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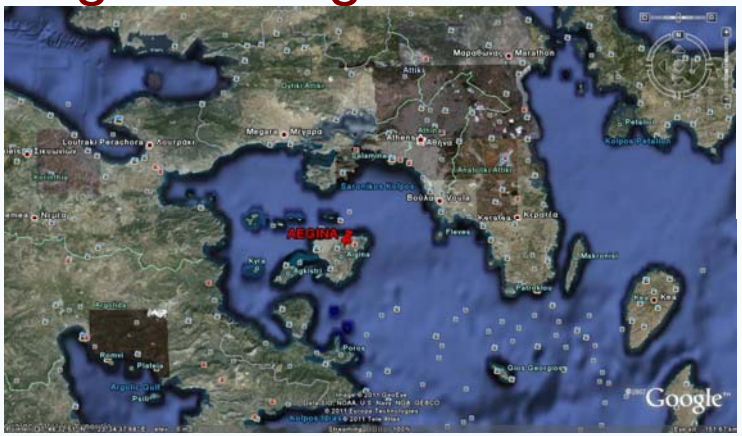
Life

AgroStrategies

Athens 2017, Friday 23 June

AgroStrat

Sustainable strategies for the improvement of seriously degraded agricultural areas: The example of *Pistachia vera* L.



LIFE11 ENV/GR/951

1/10/2012-30/9/2017
Budget: 1,026,509 €

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Department of Soil Science Athens-ELGO DEMETER

With the support of:

- Region of Attiki, Greece
- Agricultural Association of Aegina Island
- Cooperative of Pistachio producers of Aegina island

Institute for Mediterranean Studies IMS-FORTH

Technical University of Crete

During project lifetime:

- Region of Sterea Ellada, Greece
- Cooperative of Pistachio producers of Makri, Fthiotida prefecture
- Cooperative of Pistachio producers of Molos, Fthiotida prefecture

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Aims in brief……

1. Development, implementation of an integrated, recourse based scenario for the protection and improvement of serious degraded cultivated soils in the Mediterranean area.
2. Identification of pressures and practices that contribute to soil degradation, identification of soil quality indicators
3. Development of software monitoring tools for the sustainable management of intensively cultivated Mediterranean areas.
4. Development of a GIS-based Land Information System (GIS-LIS) and land suitability maps that will allow controlled and sustainable application of treated pistachio wastes and will guarantee preservation of soil quality.
5. Development of sustainable cultivation practices and re-use of treated agricultural wastes

Pistachio waste

- Pistachios are harvested between late August and early September.
- The nuts after harvest are transported to the processing facility where they are dehulled, and dried. Fresh water is used for the dehulling and from this process the main waste stream is produced, which apart from **hulls** contains also **pistachios, shells and water**.
- On average, **for 1tn of fresh nuts, 2 tn of waste are generated**.

Pistachio waste

- After the completion of the process, without separating solid waste from wastewater, farmers mainly dispose waste on soil, in sea or in wells and streams.

- **Wastewater i**s dark colored, bad smelling, has high electrical conductivity and is rich in polyphenols and inorganics.

- The **solid waste**, which mainly consists of the nuts' pericarps, is very rich in organic matter, polyphenols, and other constituents.

- Pistachio waste cannot be considered as hazardous, by the classical mean of hazardous waste definition, since it contains no heavy metals or pathogens, however, due to its very high content in polyphenols and its very high electrical conductivity (i.e. salts content) **may cause significant detrimental effects on soil quality.**

Pistachio Wastewater

Parameter	Average value	Parameter	Average value
pH	5,22	Total Fe, mg L^{-1}	0.51
EC, mS/cm	6,4	Total Zn, mg L^{-1}	1.39
COD, g L^{-1}	11,6	Total Mn, mg L^{-1}	0.68
Polyphenols, g L^{-1}	5,5	Total B, mg L^{-1}	5,5
K, g L^{-1}	1,04	NH_4^+, mg L^{-1}	9,0
Ca, % (w/v)	$2,8 \times 10^{-2}$	Cl^-, mg L^{-1}	1000
Mg, % (w/v)	$1,24 \times 10^{-2}$	NO_3^-, mg L^{-1}	102
Na, mg L^{-1}	180	PO_4^{3-}, mg L^{-1}	91
Total Cu, mg L^{-1}	0,13		

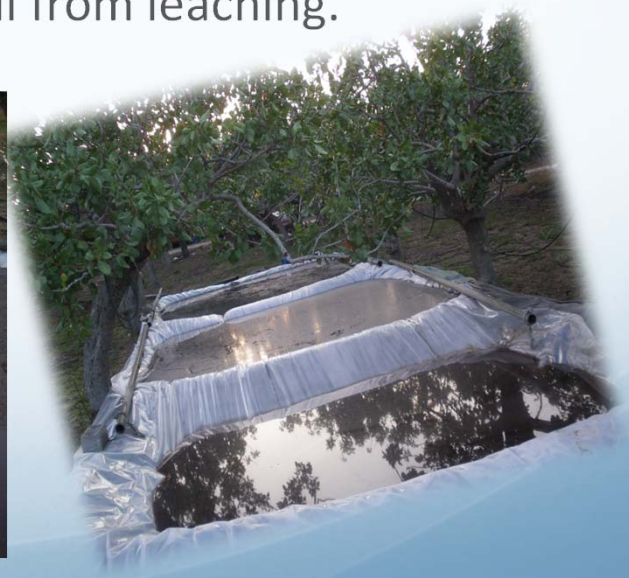
Pistachio Solid Waste

Parameter	Average value	Parameter	Average value
Organic matter, %	79	Total Cu, mg kg^{-1}	106
Total N, %	2.5	Total Fe, %	0.58
Moisture, %	60	Total Zn, mg kg^{-1}	99
pH	7.44	Total Mn, mg kg^{-1}	85
EC, mS/cm	3.8	Total B, %	0.13
Total Polyphenols, g kg^{-1}	4.5	Cl^-, mg kg^{-1}	4,900
Total K, % (as K_2O)	2.9	NO_3^-, mg kg^{-1}	1,200
Total P, % (as P_2O_5)	1.0	PO_4^{3-}, mg kg^{-1}	50
Total Ca, % (as CaO)	5.5	SO_4^{2-}, mg kg^{-1}	354
Total Mg, % (as MgO)	0.68	NH_4^+, mg kg^{-1}	308
Total Na, %	0.69		

What AgroStrat achieved at its pilot fields

1st case: Shallow Evaporation ponds

- Wastes are separated into solid and wastewater immediately after their production by using a simple separation equipment.
- The solid part is composted while wastewater is collected into three shallow ponds and left to evaporate.
- The ponds were constructed in one of the pilot fields and can be permanent or temporary.
- Protective media (geotextiles) were used to protect soil from leaching.



What AgroStrat achieved at its pilot fields

2nd case: Shallow Evaporation ponds

- The system was constructed in Aegina island by exploiting a former, almost destroyed, pig breeding area
- The five stall places were reconstructed to form a sequential system of five reservoirs for waste collection.
- Wastes are not separated after production. Instead, they are collected into the five reservoirs.
- The solid part is left to precipitate and then used for composting. Wastewater is left to evaporate

August 2016

October 2016

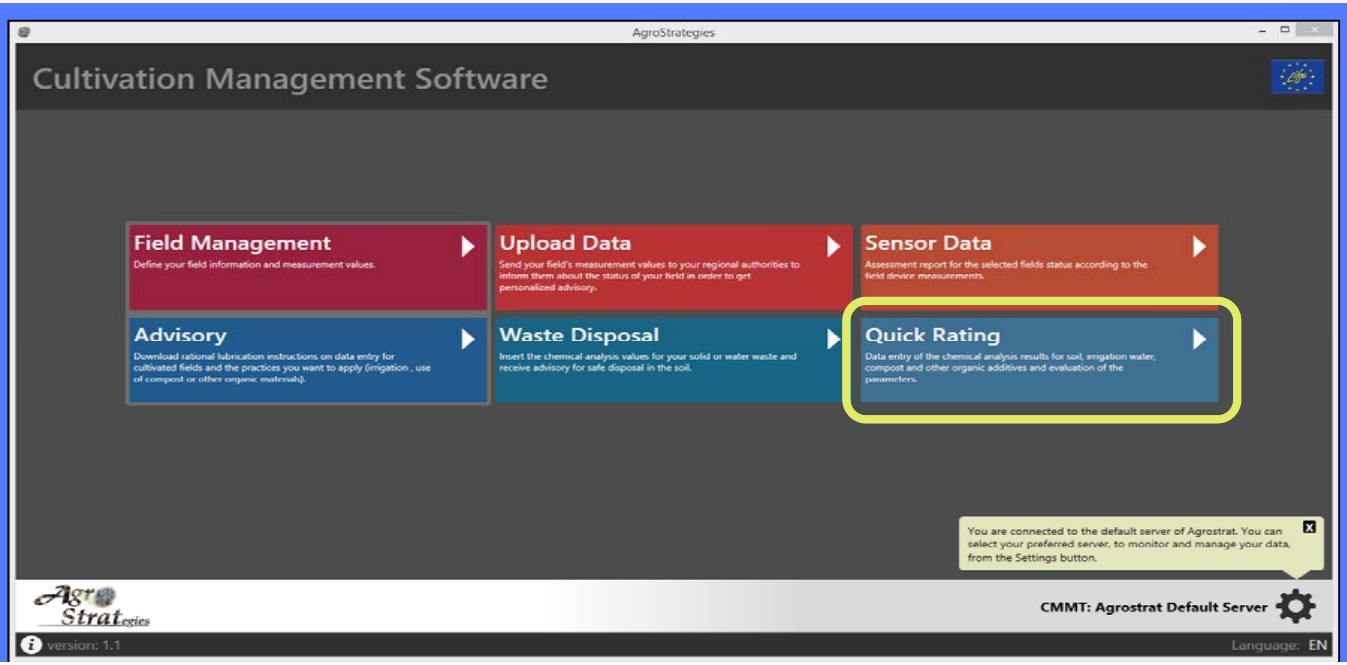

KUBOTA
Athens 2017, Friday 23 June

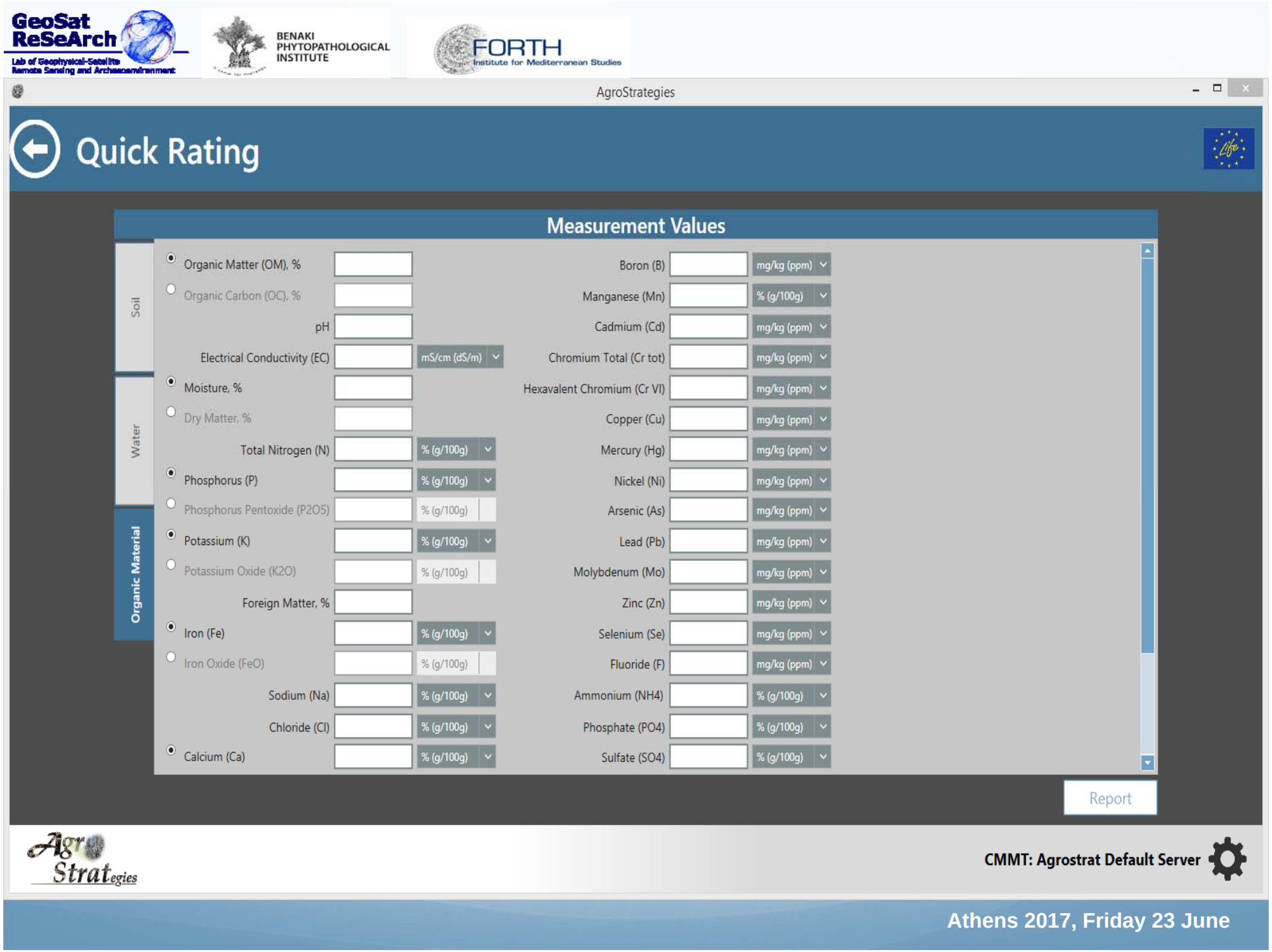
....and here comes the question

Which is the correct dose to be applied on soil?

Materials

- Wastewater
- Solid waste
- Compost

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Quick Rating
Measurement Values
Soil
Water
Organic Material
Organic Matter (OM), %
Organic Carbon (OC), %
pH
Electrical Conductivity (EC)
mS/cm (dS/m)
Moisture, %
Dry Matter, %
Total Nitrogen (N)
% (g/100g)
Phosphorus (P)
Phosphorus Pentoxide (P2O5)
Potassium (K)
Potassium Oxide (K2O)
Foreign Matter, %
Iron (Fe)
Iron Oxide (FeO)
Sodium (Na)
Chloride (Cl)
Calcium (Ca)
Boron (B)
mg/kg (ppm)
Manganese (Mn)
% (g/100g)
Cadmium (Cd)
Chromium Total (Cr tot)
Hexavalent Chromium (Cr VI)
Copper (Cu)
Mercury (Hg)
Nickel (Ni)
Arsenic (As)
Lead (Pb)
Molybdenum (Mo)
Zinc (Zn)
Selenium (Se)
Fluoride (F)
Ammonium (NH4)
Phosphate (PO4)
Sulfate (SO4)
Report
AgroStrategies
CMMT: Agrostrat Default Server
Athens 2017, Friday 23 June

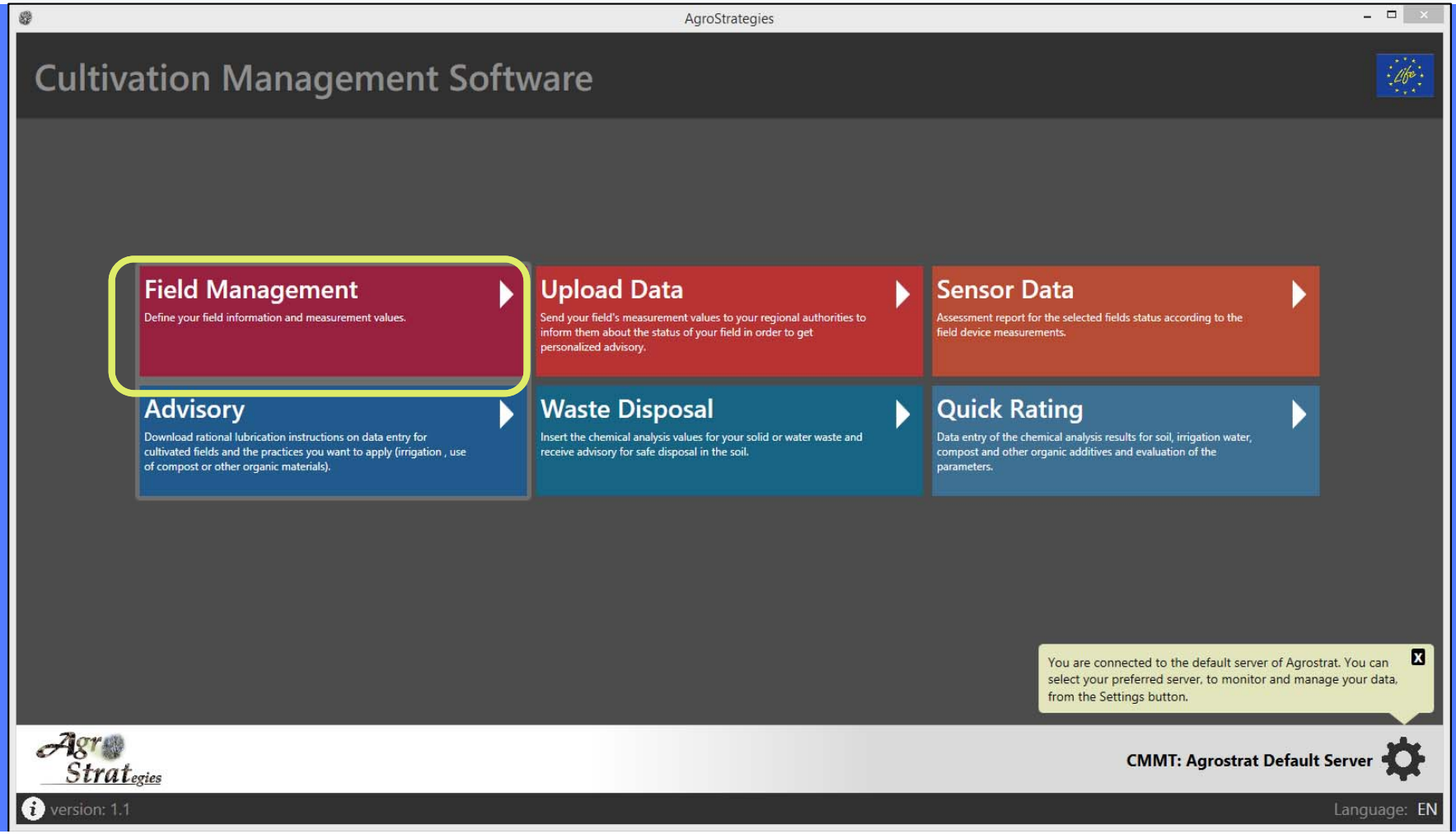
Evaluation Report

Soil
Water
Compost

Parameter	Value	Evaluation
pH	6	The pH value is low and an expert advice is recommended. Low pH may cause problems to acid soils and also mobilization of heavy metals.
Organic Matter	52 %	Organic matter is considered satisfactory. In general materials with organic matter between 16-38% are suitable for field application while materials with organic matter higher than 19.4% are suitable for nursery application. Moreover, due to the high organic matter content, the material can be awarded with an ECO-label according to the COM Decision (EC) n° 799/2006 for soil improvers.
Electrical Conductivity	8 mS/cm (dS/m)	The electrical conductivity is high and the application of the material may cause salt accumulation, toxicities to plants and soil salinization. An expert advice is strongly recommended.
Moisture	50 %	The moisture of the materials is within normal values range and satisfies also the COM Decision (EC) n° 799/2006 for soil improvers that can be awarded with an EU ECO label.
Total Nitrogen (N)	0.51 %	Total nitrogen content is satisfactory and satifies also the COM Decision (EC) n° 799/2006 for soil improvers that can be awarded with an EU ECO label. The lowest acceptable N concentration is 2%. ThErefore a nitrogen content between 2 and 3% is acceptable.
Inorganic nitrogen content	0.065 %	The inorganic form of nitrogen is lower than the 20% of the total nitorgen and the material is considered safe for soil application. However, all other

….but the software estimates also the correct dose to be distributed on soil

- For fertilizing pistachio trees
- Just to dispose off



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AgroStrategies

Field Data

Add Field Information

Field Name:
EXAMPLE

Field Description:
ATHENS2017

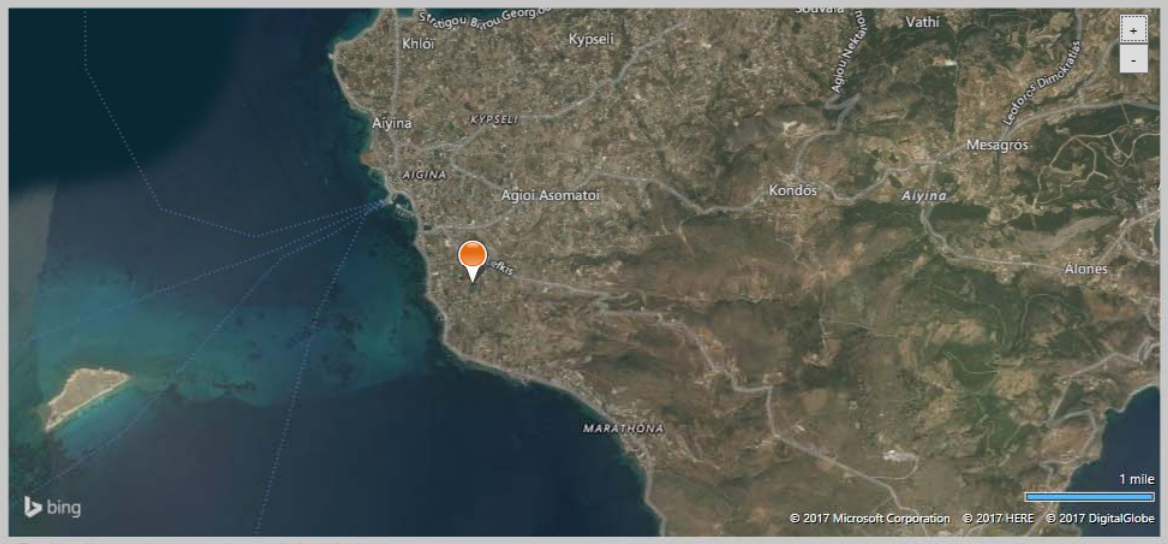
Area: 2 stremma

Country: Greece

Latitude: 37.735328

Longitude: 23.438122

Select field's location:



(Double click on the map to insert pin location)

Cancel Save

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….but the software estimates also the correct dose to be distributed on soil

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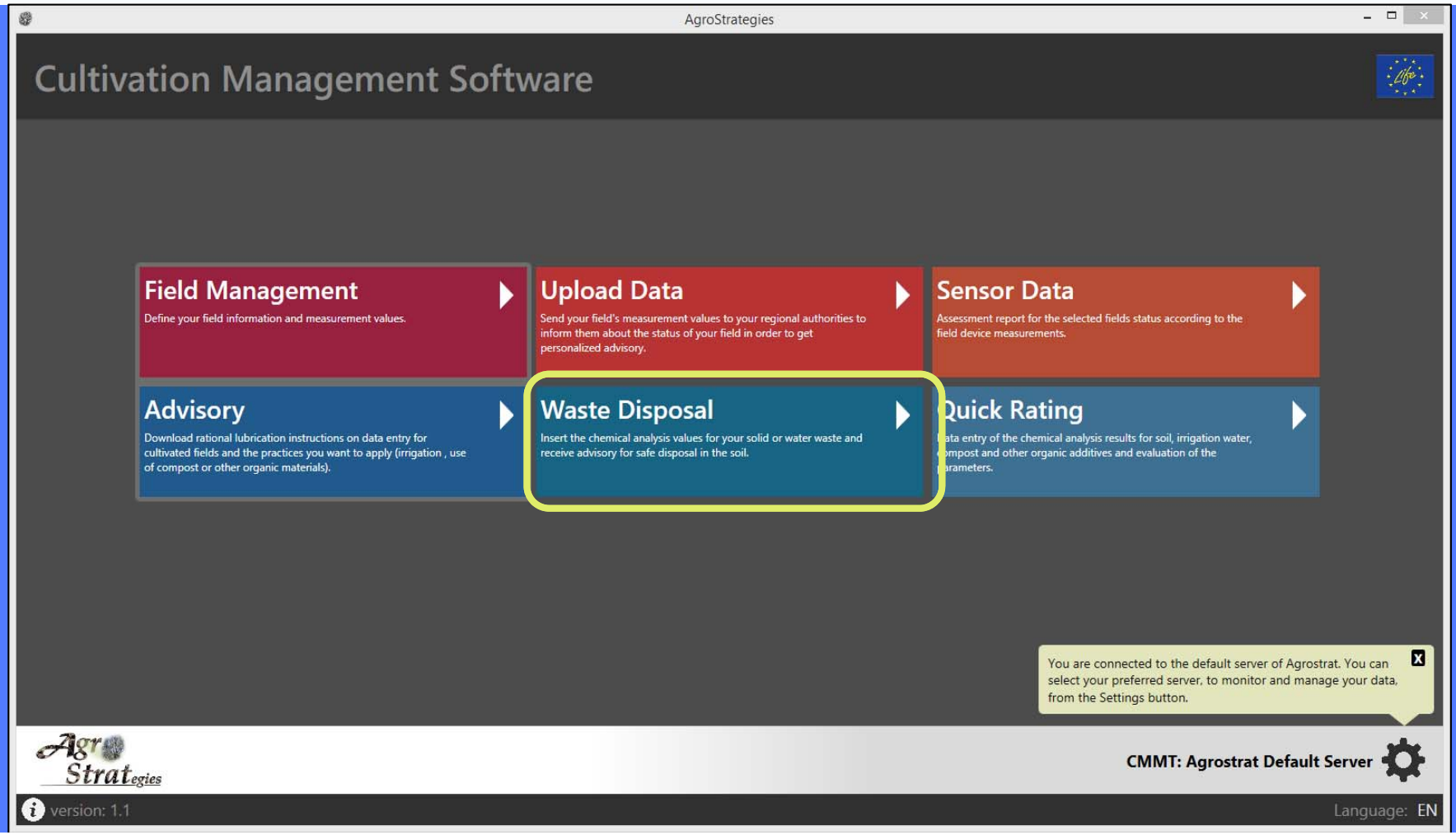

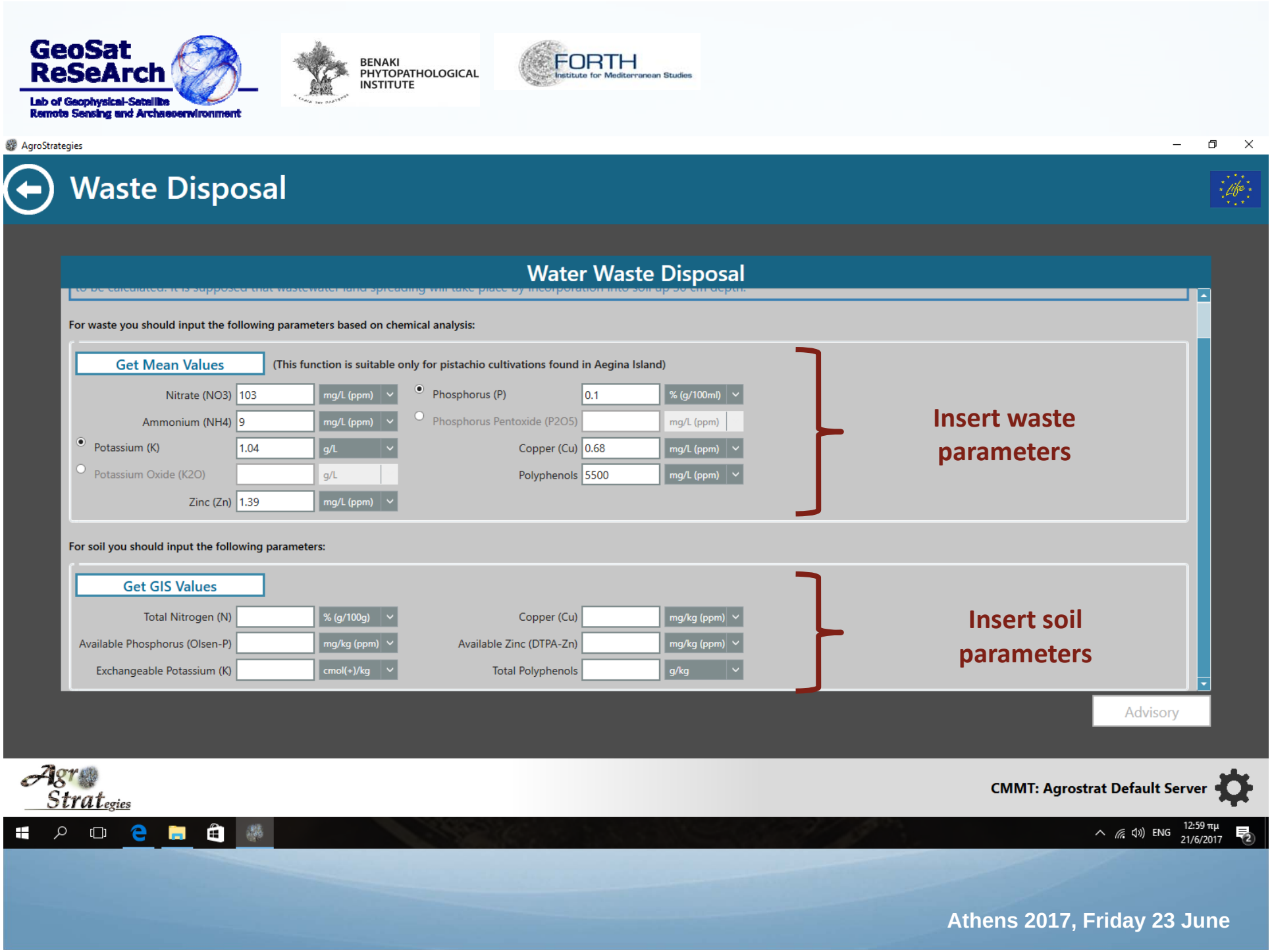
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AgroStrategies
Waste Disposal
Water Waste Disposal
For waste you should input the following parameters based on chemical analysis:
Get Mean Values
(This function is suitable only for pistachio cultivations found in Aegina Island)
Nitrate (NO3) 103 mg/L (ppm)
Ammonium (NH4) 9 mg/L (ppm)
Potassium (K) 1.04 g/L
Potassium Oxide (K2O) g/L
Zinc (Zn) 1.39 mg/L (ppm)
Phosphorus (P) 0.1 % (g/100ml)
Phosphorus Pentoxide (P2O5) mg/L (ppm)
Copper (Cu) 0.68 mg/L (ppm)
Polyphenols 5500 mg/L (ppm)
Insert waste parameters
For soil you should input the following parameters:
Get GIS Values
Total Nitrogen (N) % (g/100g)
Available Phosphorus (Olsen-P) mg/kg (ppm)
Exchangeable Potassium (K) cmol(+)/kg
Copper (Cu) mg/kg (ppm)
Available Zinc (DTPA-Zn) mg/kg (ppm)
Total Polyphenols g/kg
Insert soil parameters
Advisory
AgroStrategies
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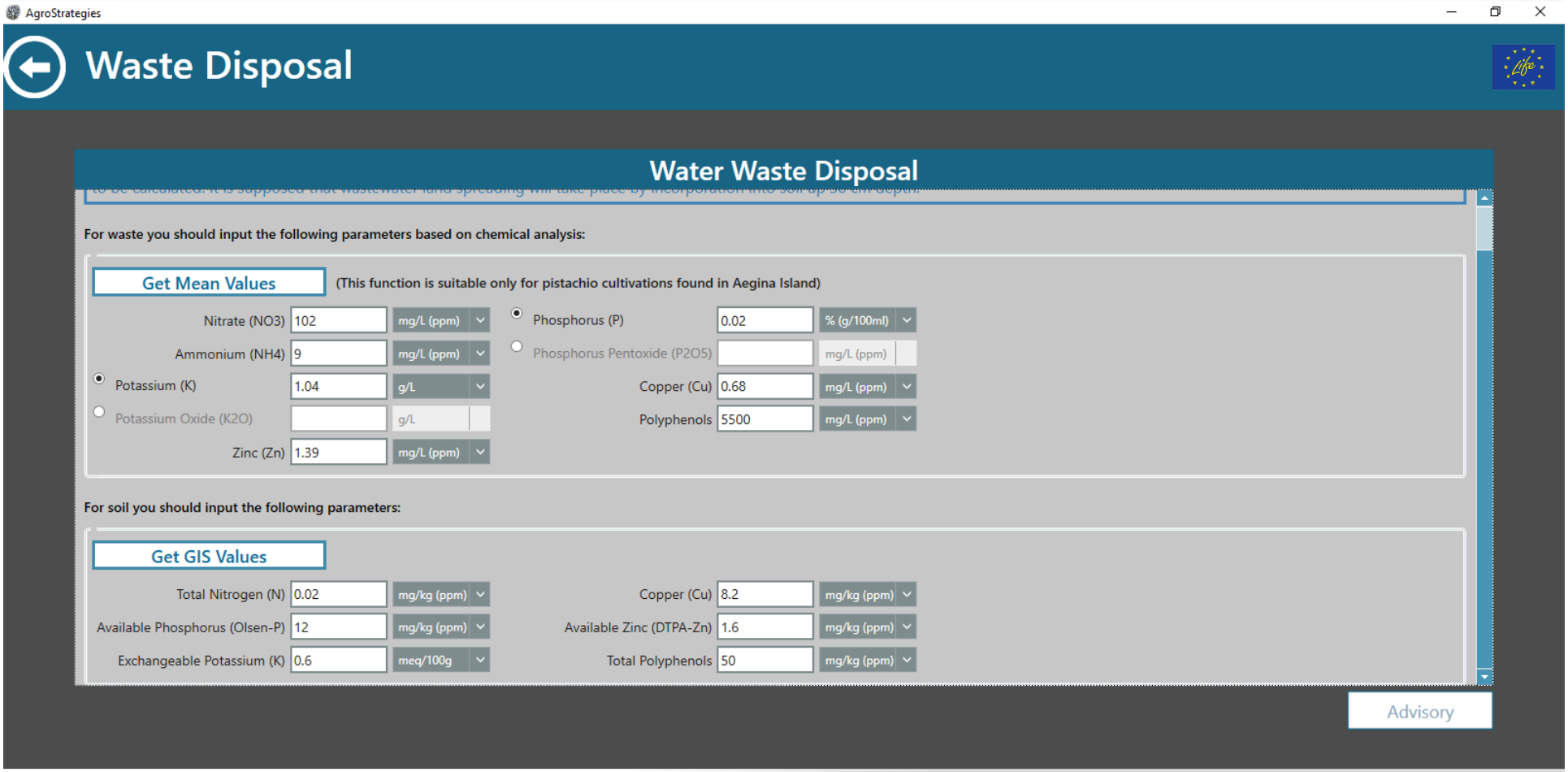

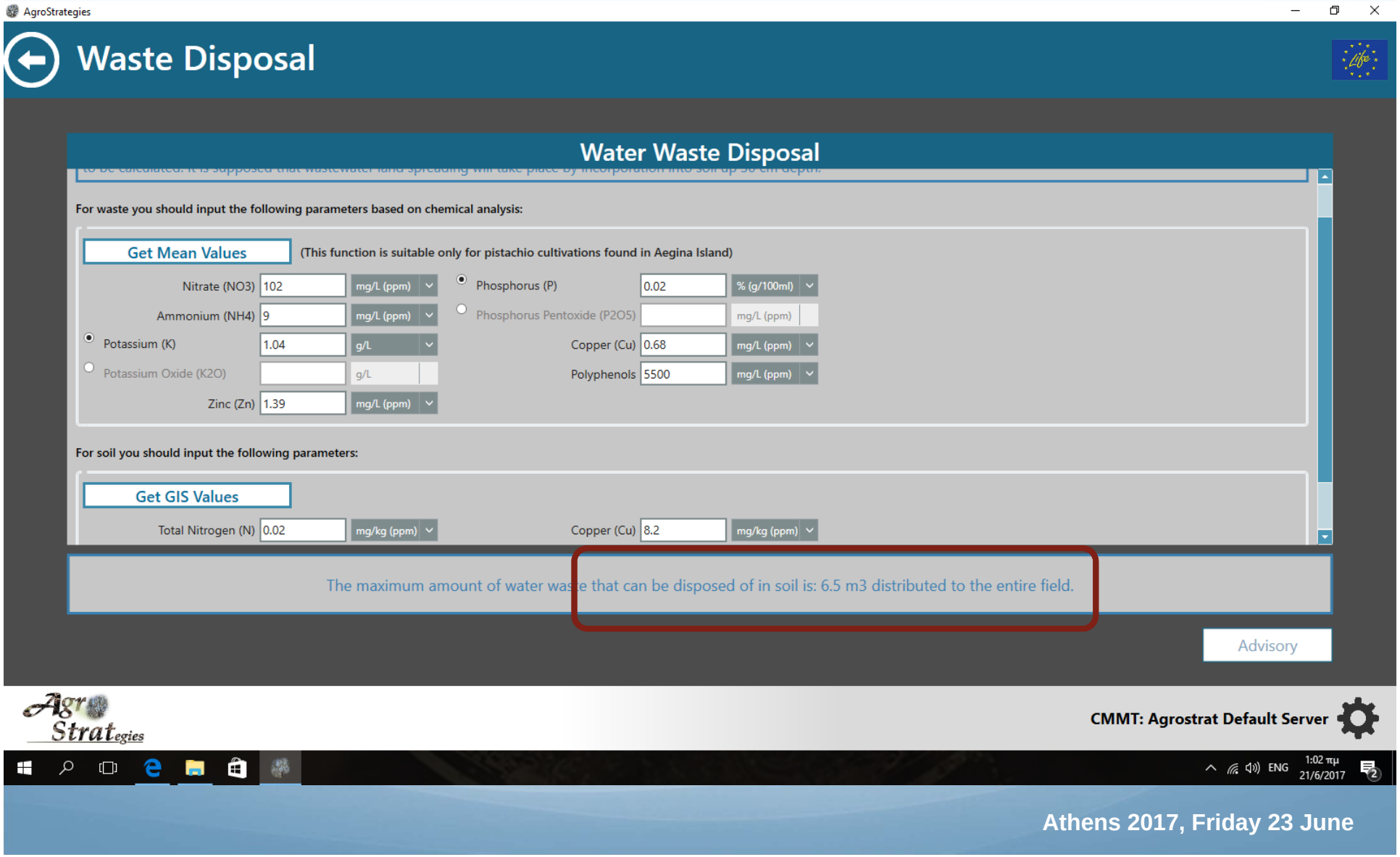
AgroStrategies
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Ammonium (NH4) 9 mg/L (ppm)
Potassium (K) 1.04 g/L
Potassium Oxide (K2O) g/L
Zinc (Zn) 1.39 mg/L (ppm)
Phosphorus (P) 0.02 % (g/100ml)
Phosphorus Pentoxide (P2O5) mg/L (ppm)
Copper (Cu) 0.68 mg/L (ppm)
Polyphenols 5500 mg/L (ppm)
For soil you should input the following parameters:
Get GIS Values
Total Nitrogen (N) 0.02 mg/kg (ppm)
Copper (Cu) 8.2 mg/kg (ppm)
The maximum amount of water waste that can be disposed of in soil is: 6.5 m3 distributed to the entire field.
Advisory
CMMT: Agrostrat Default Server
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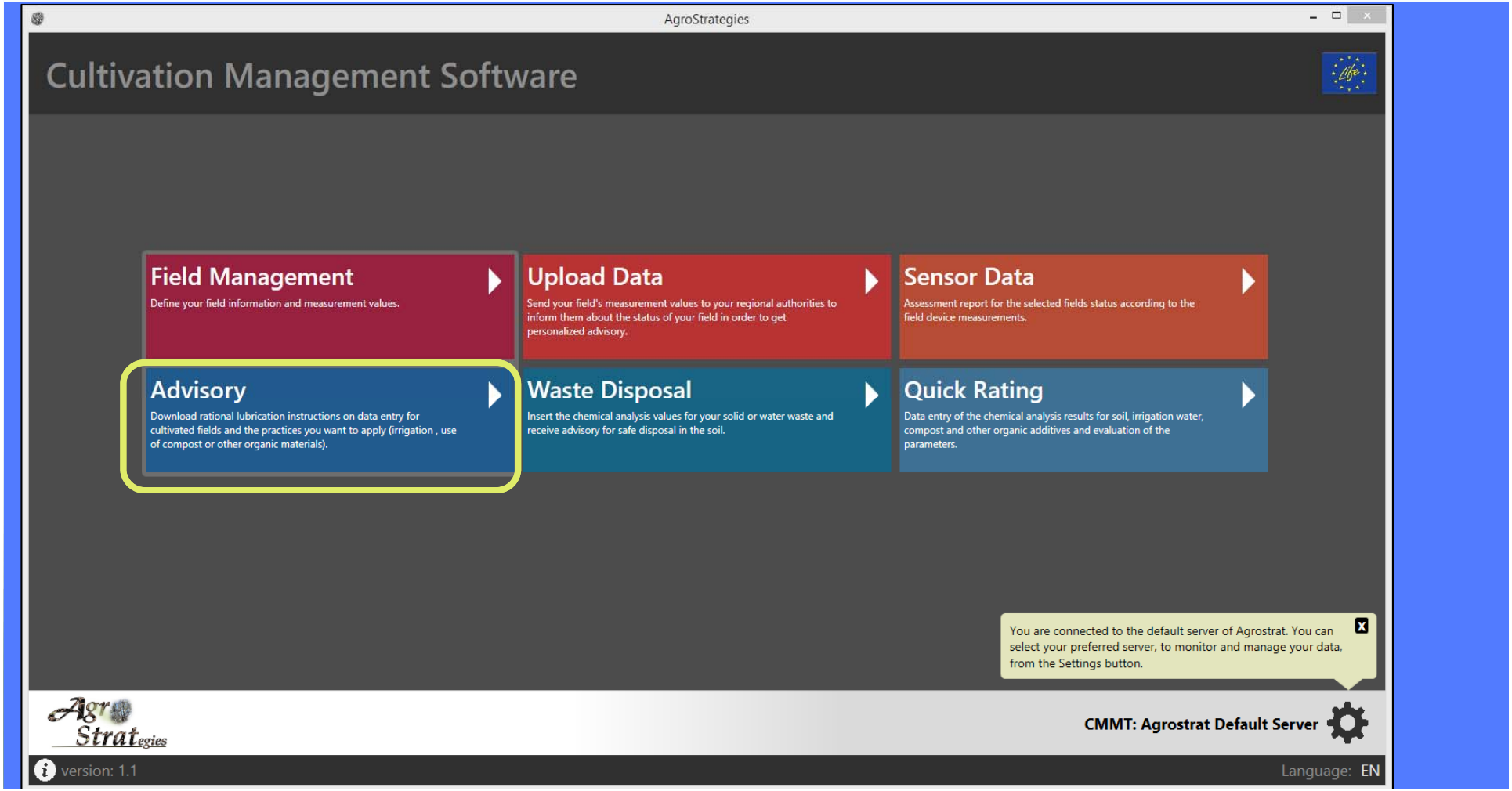


Advisory Report

Soil Advisory

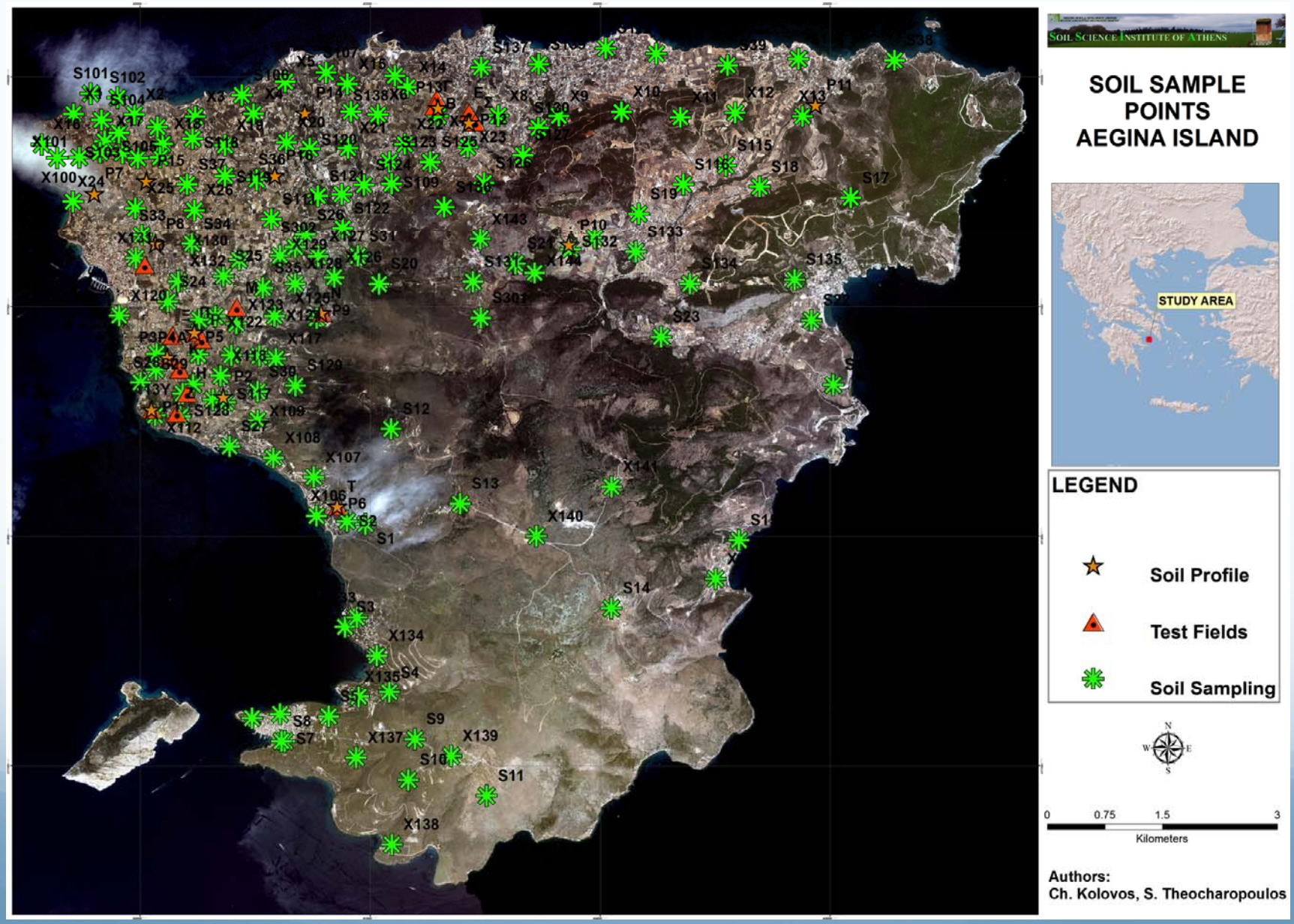
Element	Advisory
Nitrogen (N)	Recommended dose 8.6Kg/1000m2. Broadcast the fetilizer during orchard establishment and incorporate into soil. Apply 0.77 tns of the organic material on soil surface. It is suggested to broadcast the fertilizer and the organic material all over the field.
Phosphorus (P)	Apply the whole recommended phosphorus rate of 38Kg/1000m2. before or during bud swelling period. Divide the recommended fertilizer amount according to the number of field trees, broadcast fertilizer under the canopy and incorporate into soil. Broadcast the organic material on soil surface all over the field. During the off-period it is recommended to use the half phosphorus fertilization rate.
Potassium (K)	The needed potassium amount can be provided by proadcasting 0.77 tons of the organic material. Therefore, no addditional potassium fertilization is needed.

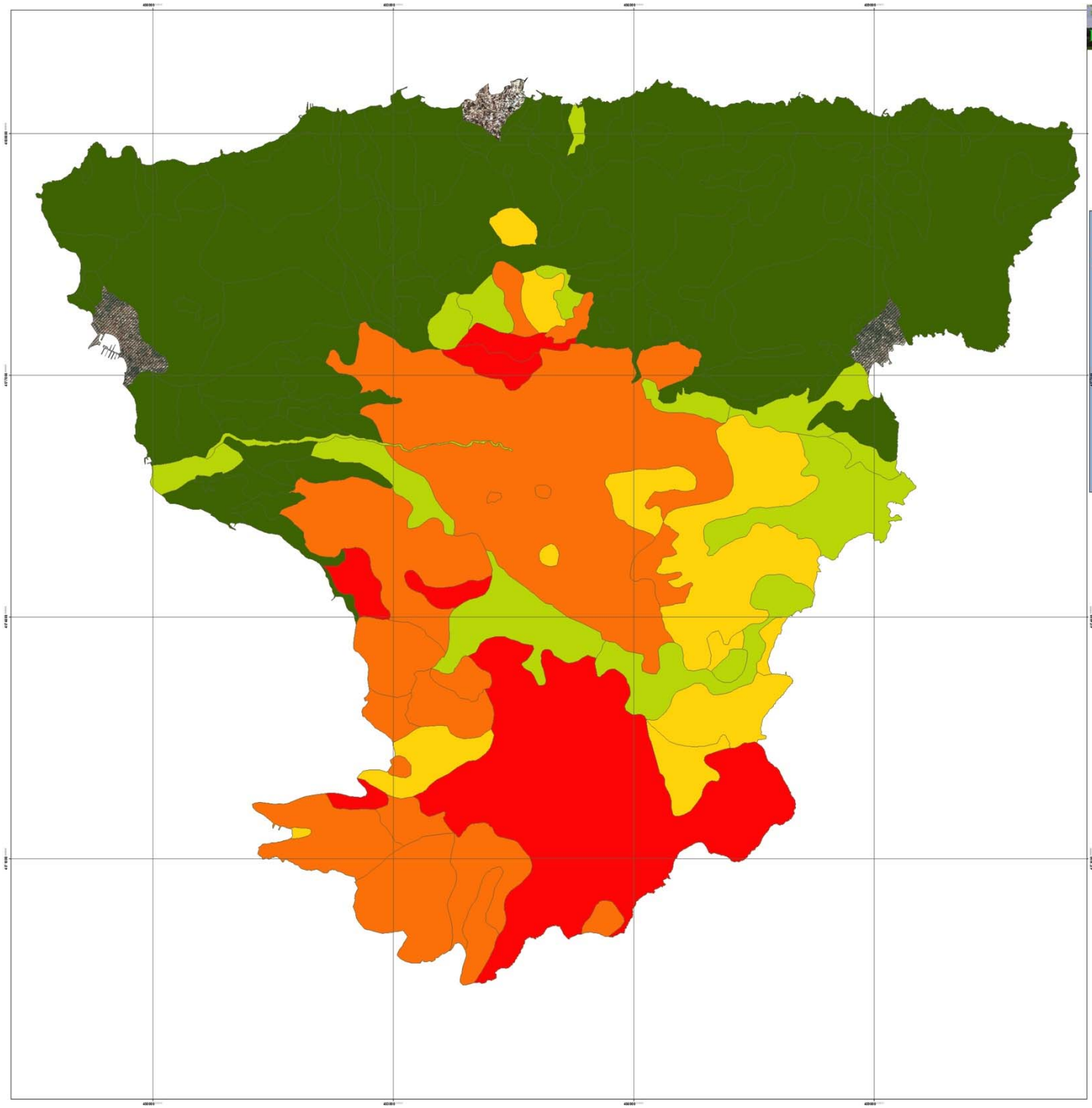
Compost Advisory

In order to assess the suitability of the organic material for landspreading according to the national and the EU legislative framework, you must enter the concentrations of heavy metals contained in soil and organic material (total forms). The proposed consultancy have no legal basis.
Σύμφωνα με τα στοιχεία που δηλώσατε, η μέγιστη ποσότητα οργανίκου υλικού, η οποία μπορεί να χρησιμοποιηθεί στα 1 στρέμματα του χωραφιού σας είναι 0.77 τόνοι.

What is behind the software

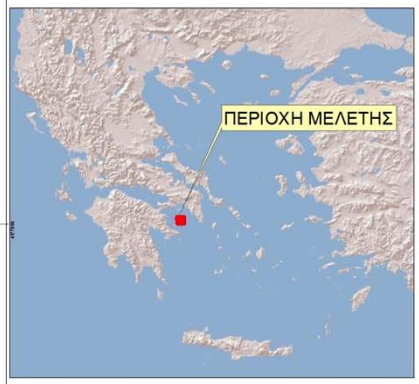
23 Soil Thematic Maps





ΙΝΣΤΙΤΟΥΤΟ ΕΔΑΦΟΛΟΓΙΑΣ ΑΘΗΝΩΝ

Soil $CaCO_3$



ΥΠΟΜΝΗΜΑ

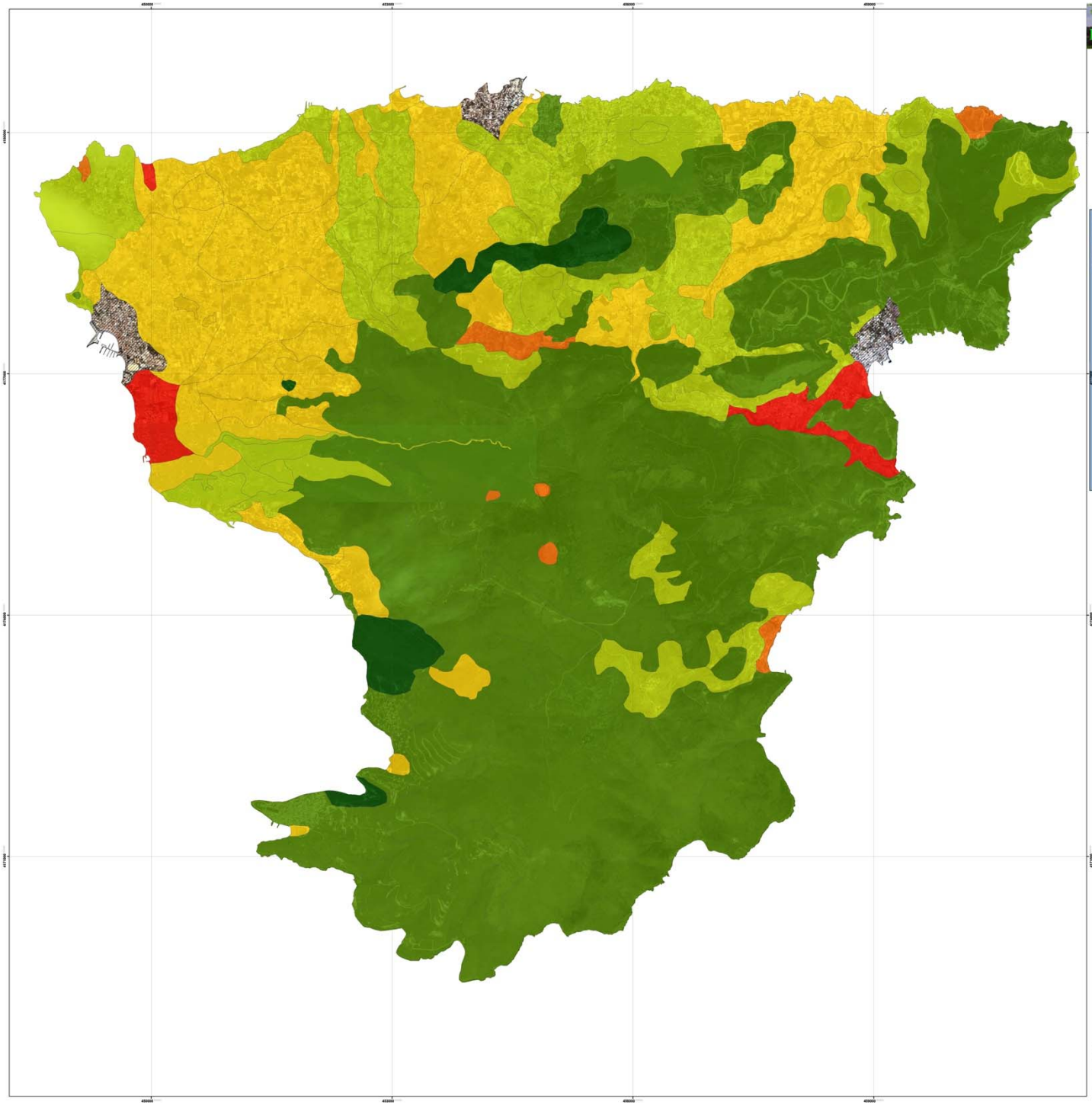
TOT_CACO3_

- 0.00
- 0.01 - 1.00
- 1.01 - 5.00
- 5.01 - 10.00
- 10.01 - 20.00
- >20
- URBAN

N
W E
S

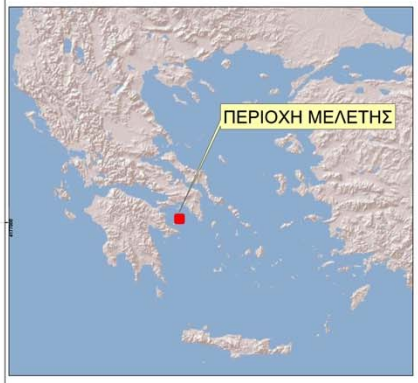
1.5 0.75 0 1.5
Kilometers

Συντάξαντες:
Χ. Κολοβός, Σ. Θεοχαρόπουλος



ΙΝΣΤΙΤΟΥΤΟ ΕΔΑΦΟΛΟΓΙΑΣ ΑΘΗΝΩΝ

Soil Depth



ΥΠΟΜΝΗΜΑ

Βάθος Εδάφους (cm)

- **0-15**
- **15-30**
- **30-60**
- **60-100**
- **100-150**
- **>150**
- URBAN

N
W E
S

1.5 0.75 0 1.5
Kilometers

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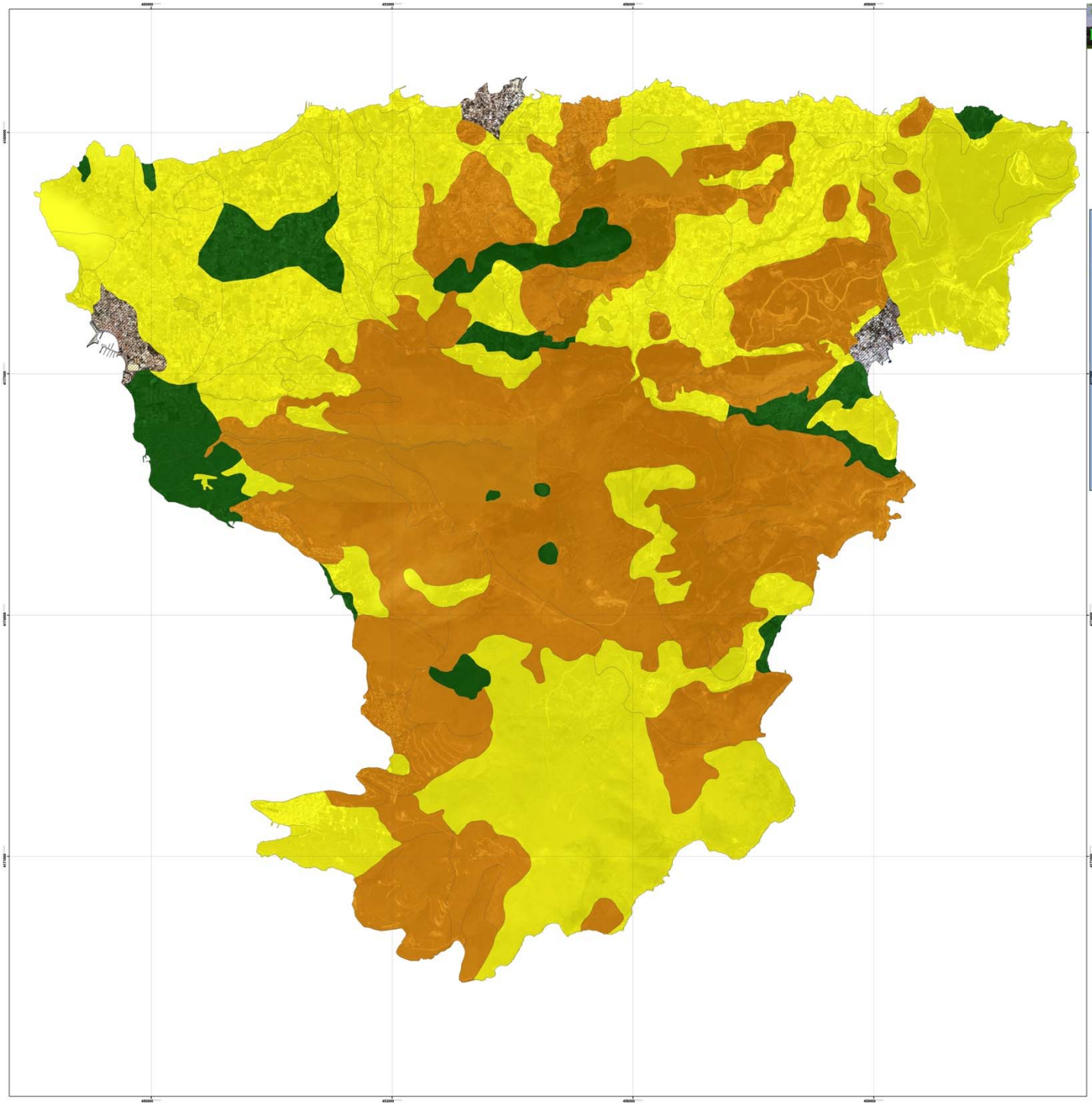

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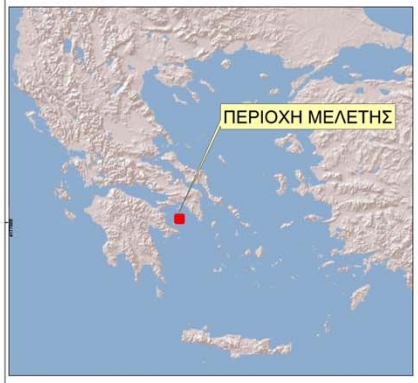
Erosion Risk



ΥΠΟΜΝΗΜΑ

ΔΙΑΒΡΩΣΗ

- ΚΑΜΙΑ ΔΙΑΒΡΩΣΗ
- ΑΣΘΕΝΗΣ ΔΙΑΒΡΩΣΗ
- ΜΕΤΡΙΑ ΔΙΑΒΡΩΣΗ
- URBAN

N
W E
S

1.5 0.75 0 1.5
Kilometers

Συντάξαντες:
Χ. Κολοβός, Σ. Θεοχαρόπουλος

Soil Map

ΥΠΟΜΝΗΜΑ

ΧΑΡΤΟΓΡΑΦΙΚΗ ΕΔΑΦΙΚΗ ΜΟΝΑΔΑ

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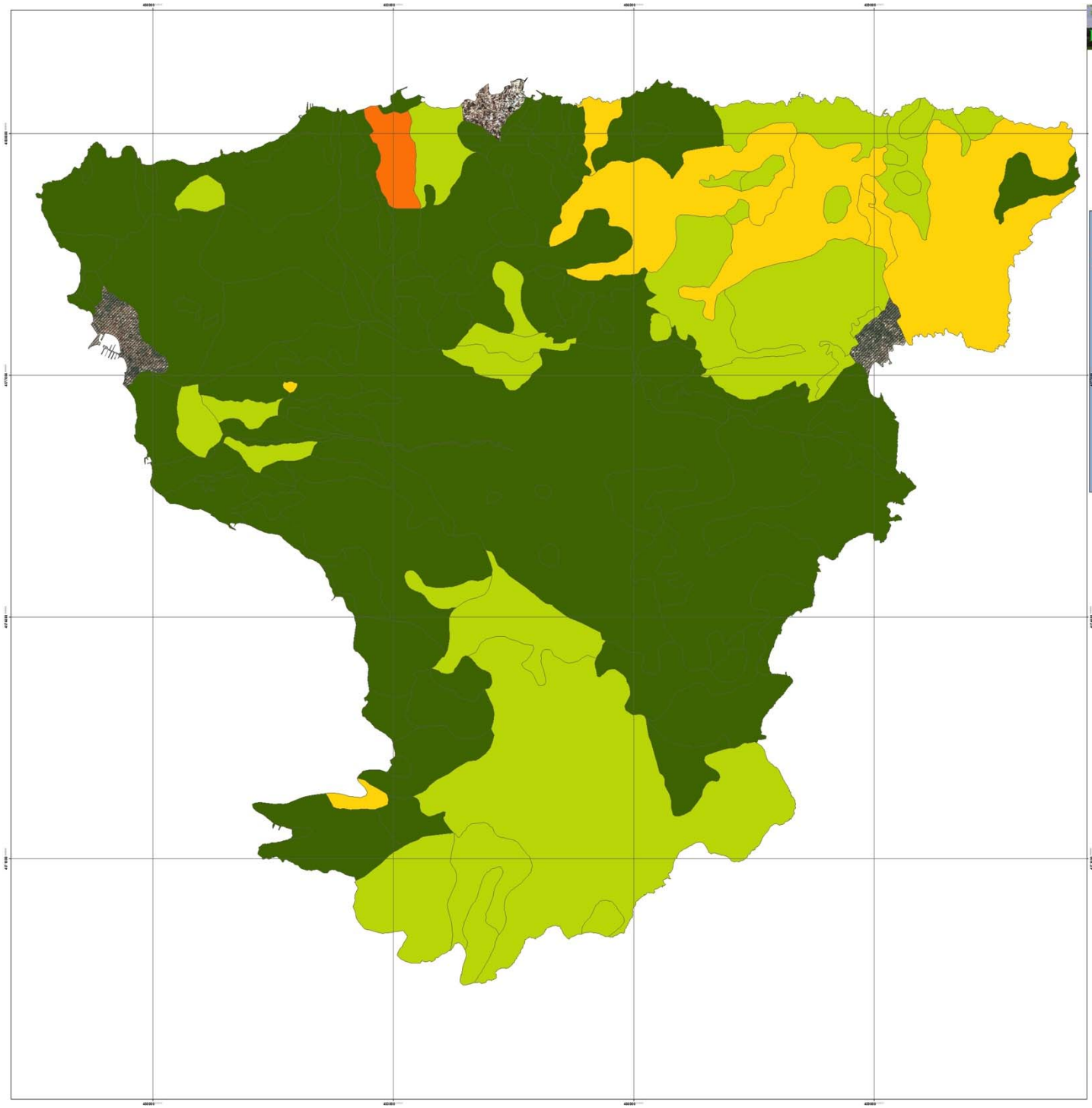
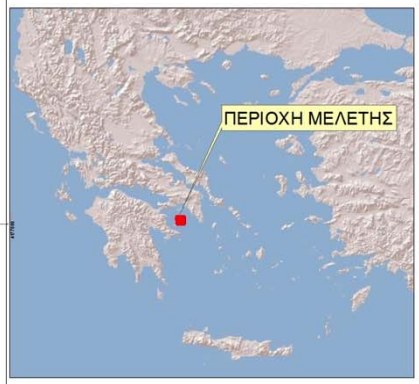


ΙΝΣΤΙΤΟΥΤΟ ΕΔΑΦΟΛΟΓΙΑΣ ΑΘΗΝΩΝ

Soil Potassium



ΥΠΟΜΝΗΜΑ

K_MEQ_100G

- 0.000
- 0.001 - 0.129
- 0.130 - 0.255
- 0.256 - 0.384
- 0.385 - 0.639
- >0.639
- URBAN

N
W E
S

1.5 0.75 0 1.5
Kilometers

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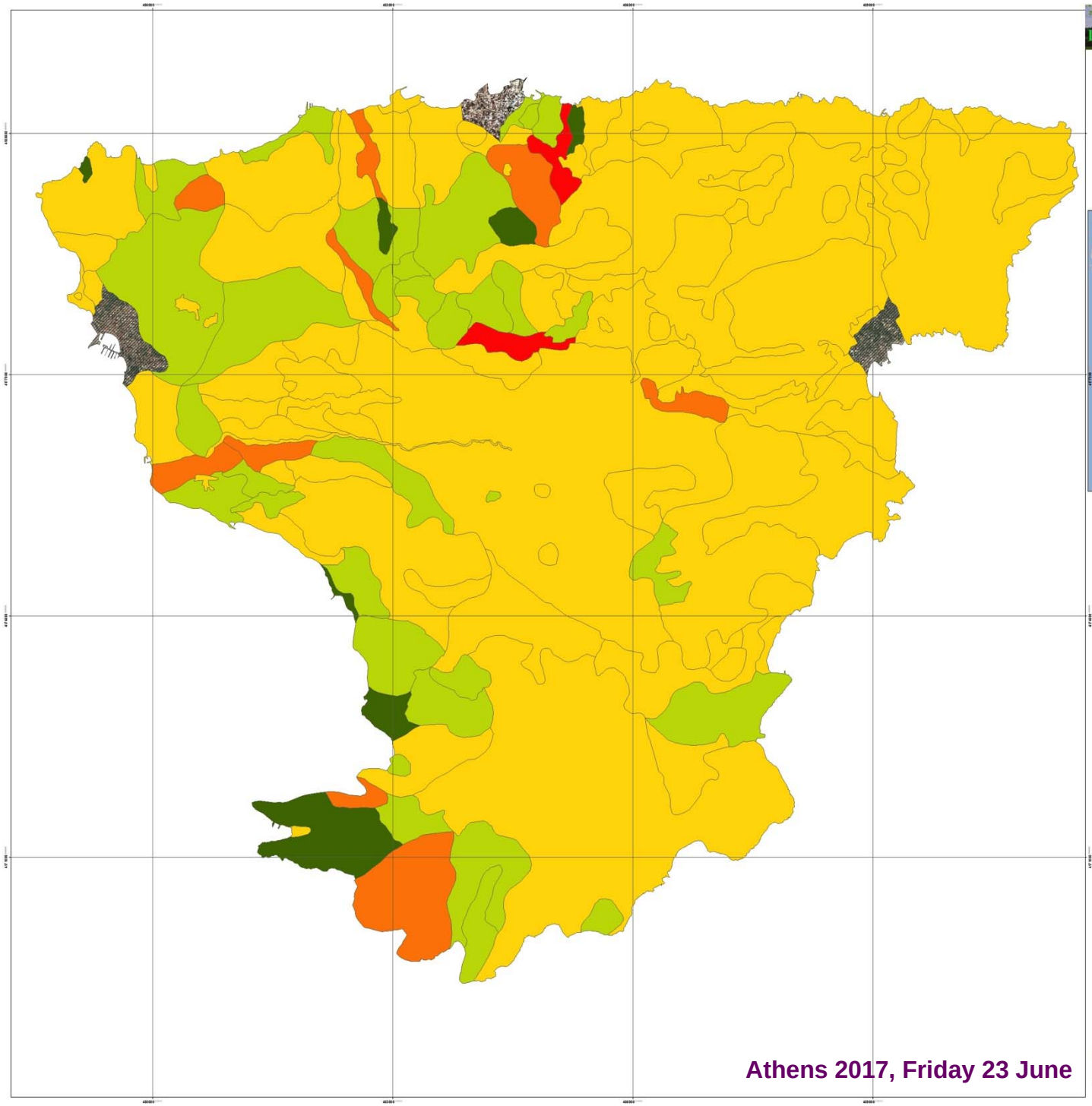
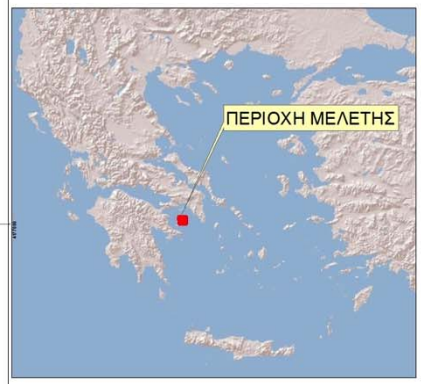


ΙΝΣΤΙΤΟΥΤΟ ΕΔΑΦΟΛΟΓΙΑΣ ΑΘΗΝΩΝ

Soil Organic Matter



ΥΠΟΜΝΗΜΑ

ORGANIC_MA

- 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 5.00
- >5
- URBAN

N
W E
S

1.5 0.75 0 1.5
Kilometers

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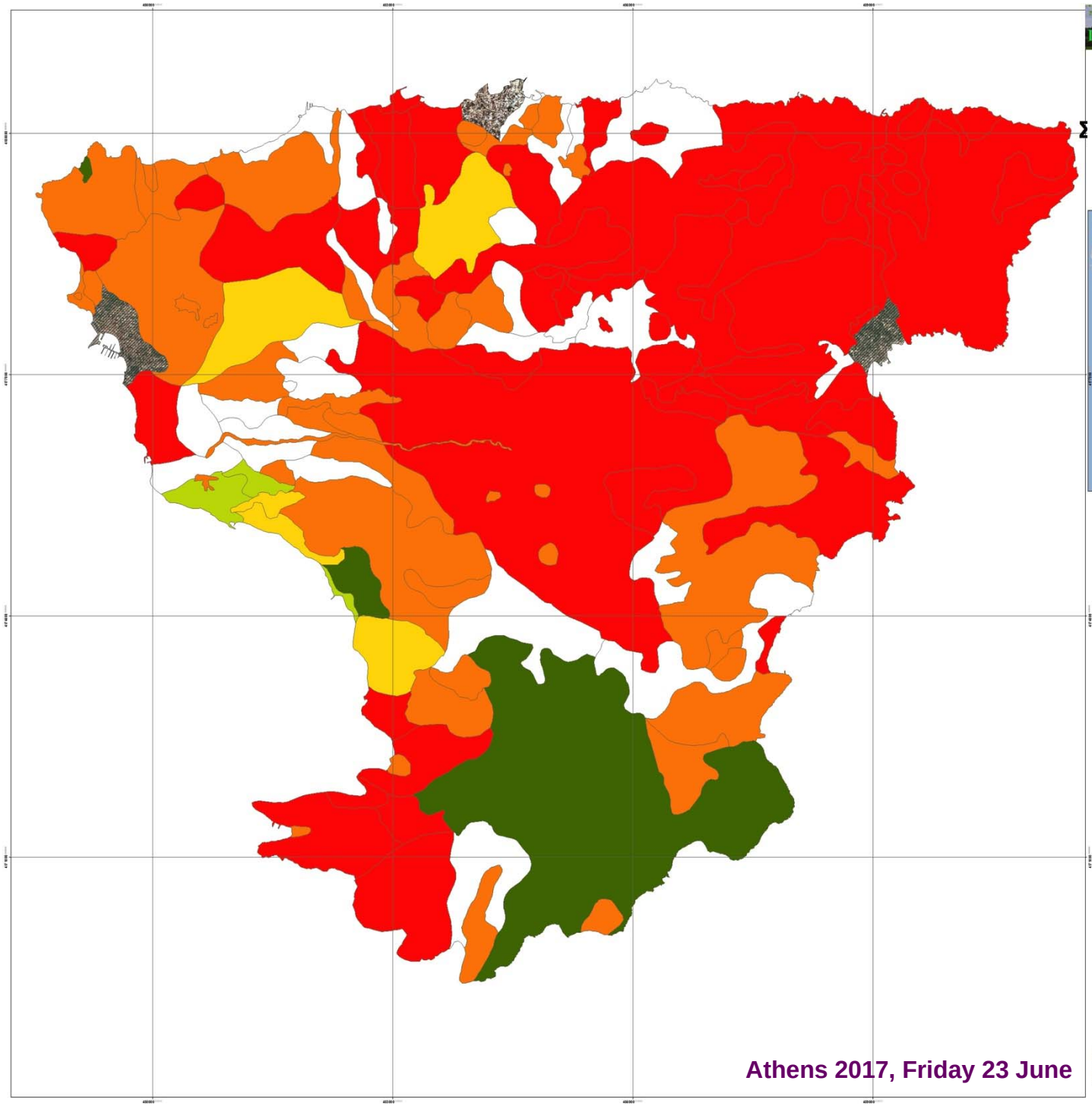
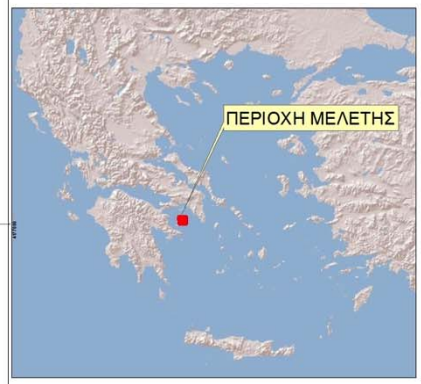


ΙΝΣΤΙΤΟΥΤΟ ΕΔΑΦΟΛΟΓΙΑΣ ΑΘΗΝΩΝ

Soil Phosphorus



ΥΠΟΜΝΗΜΑ

P_MG_KG

- 0.00
- 0.01 - 5.00
- 5.01 - 15.00
- 15.01 - 25.00
- 25.01 - 45.00
- >45
- URBAN

N
W E
S

1.5 0.75 0 1.5
Kilometers

Athens 2017, Friday 23 June

Συντάξαντες:
Χ. Κολοβός, Σ. Θεοχαρόπουλος

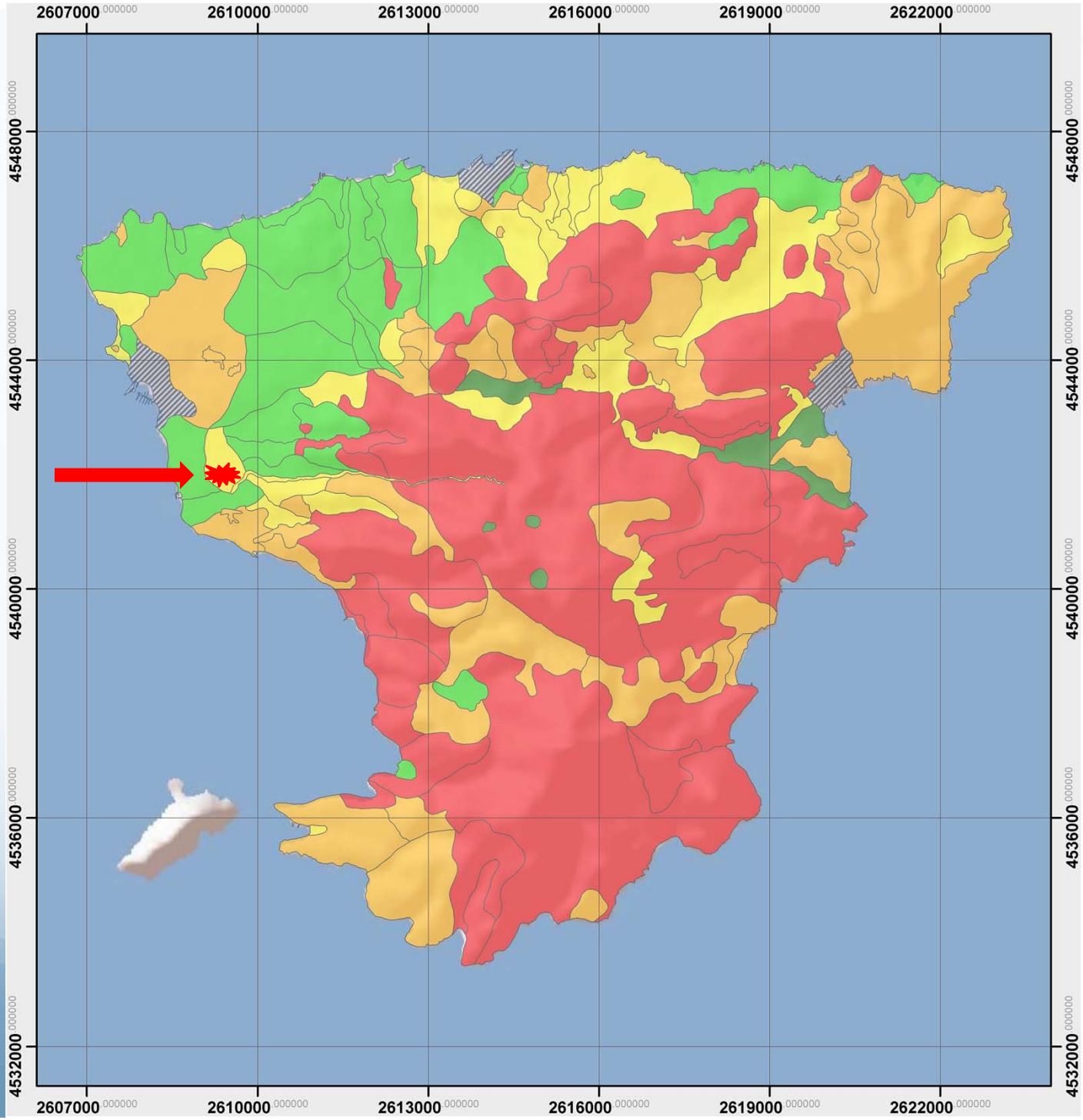
…meaning that we know soil properties everywhere on the island

….then we evaluated soils as regards the suitabilty to accept wastes

…by applying the FAO evaluation methodology

…with which one can classify soils into suitability classes by rating pre-selected properties

LAND SUITABILITY MAPS FOR WASTE REUSE ON SOILS



Agro Strategies

Life

Land suitability map for the disposal of pistachio processing wastewater

LEGEND

Areas characterization for disposal of wastewater

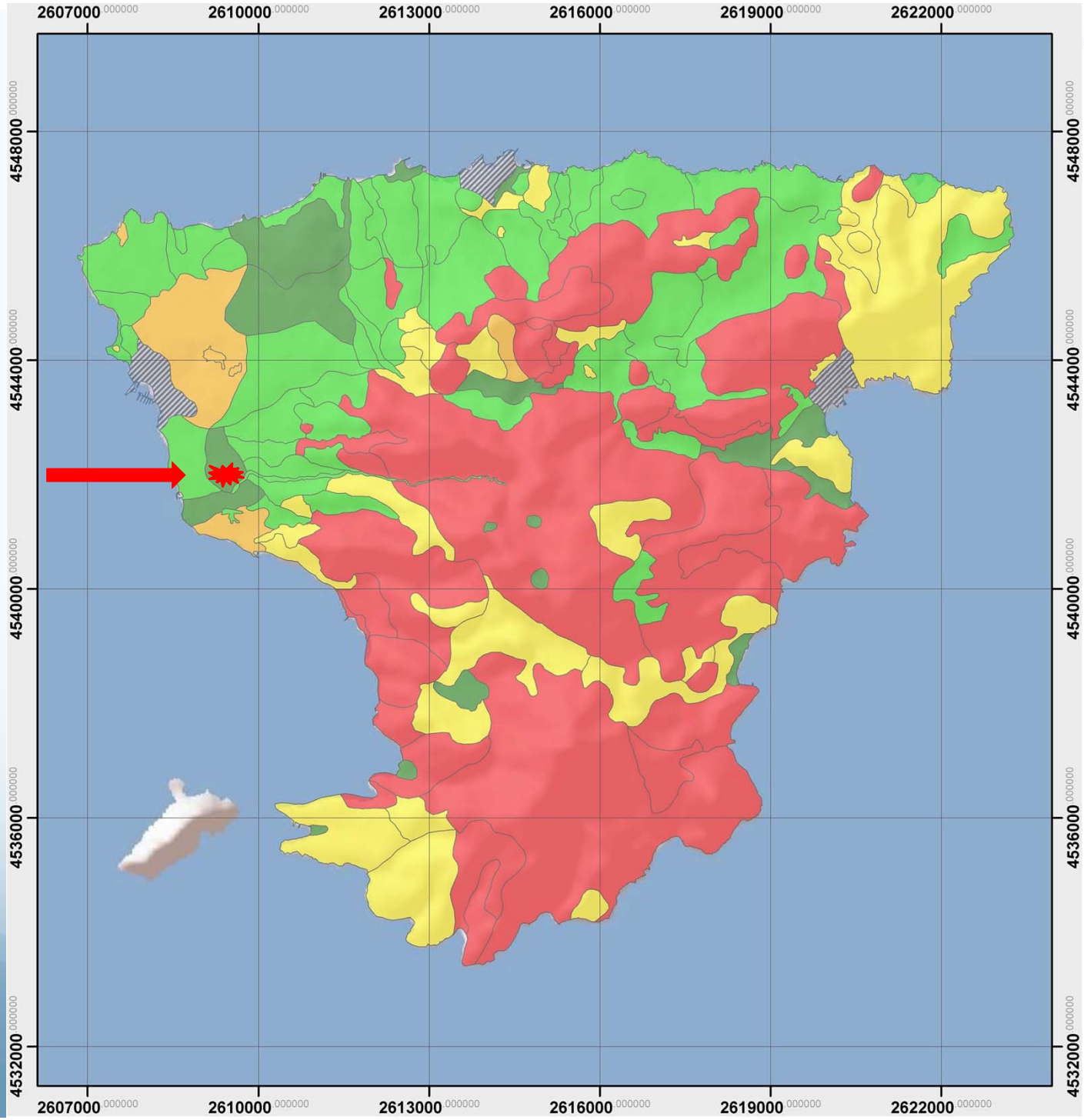
- S1 : Suitable
- S2 : Moderately suitable
- S3 : Marginally suitable
- N1 : Temporarily unsuitable
- N2 : Permanently unsuitable
- URBAN

N
W
E
S

2 1 0 2
Kilometers

Soil data processing, analysis an evaluation:
Dr. Maria Doula (Benaki Phytopathological Institute)

Soil sampling and soil characterization:
Dr. Sid Theocharopoulos, Chronis Kolovos (ELGO DEMETER)



Agro Strategies

Life

Land suitability map for the disposal of pistachio processing solid waste

LEGEND

Areas characterization for solid waste disposal

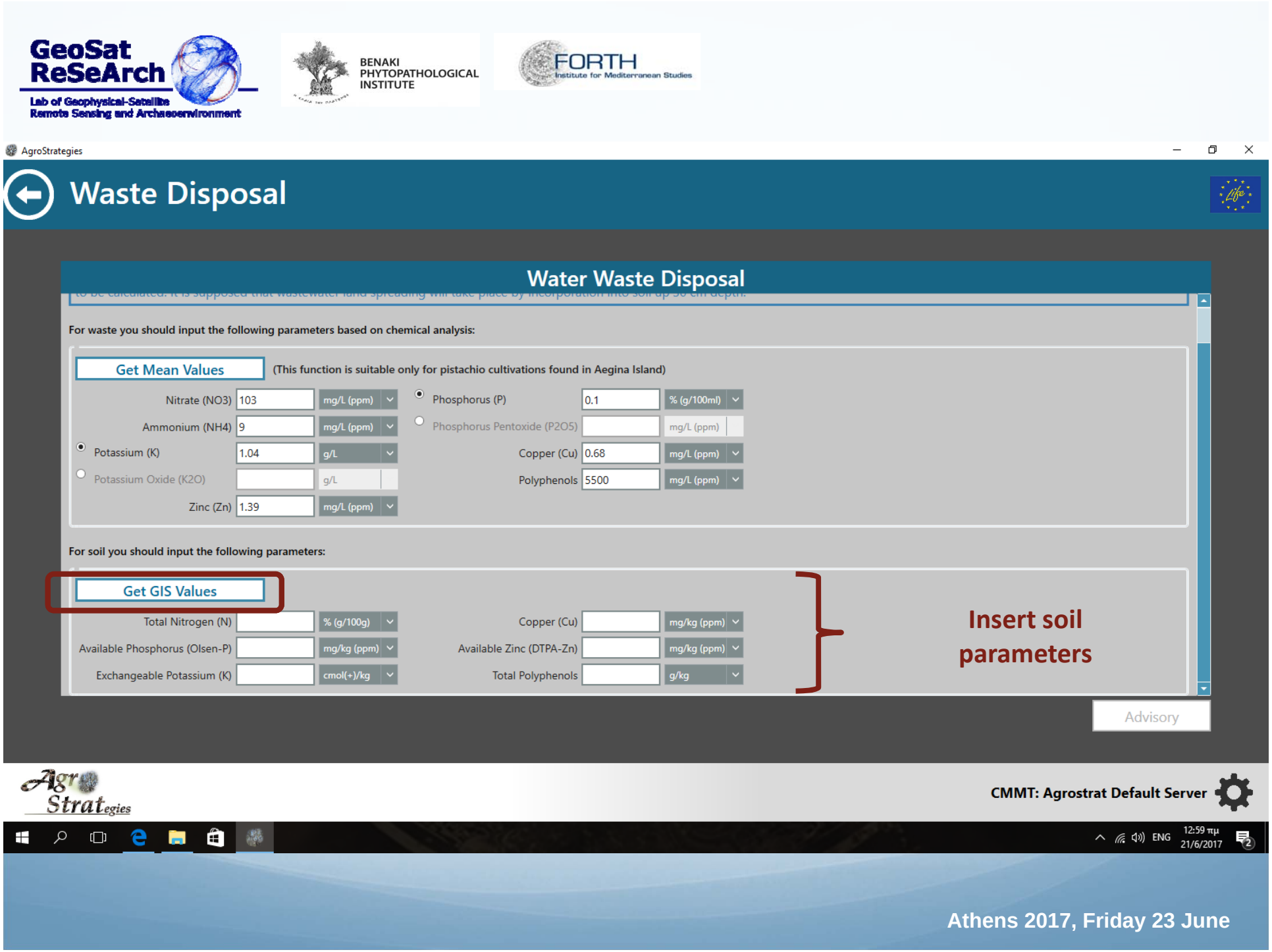
- **S1** : Suitable
- **S2** : Moderately suitable
- **S3** : Marginally suitable
- **N1** : Temporarily unsuitable
- **N2** : Permanently unsuitable
- URBAN

N W E S

2 1 0 2
Kilometers

Soil data processing, analysis an evaluation:
Dr. Maria Doula (Benaki Phytopathological Institute)

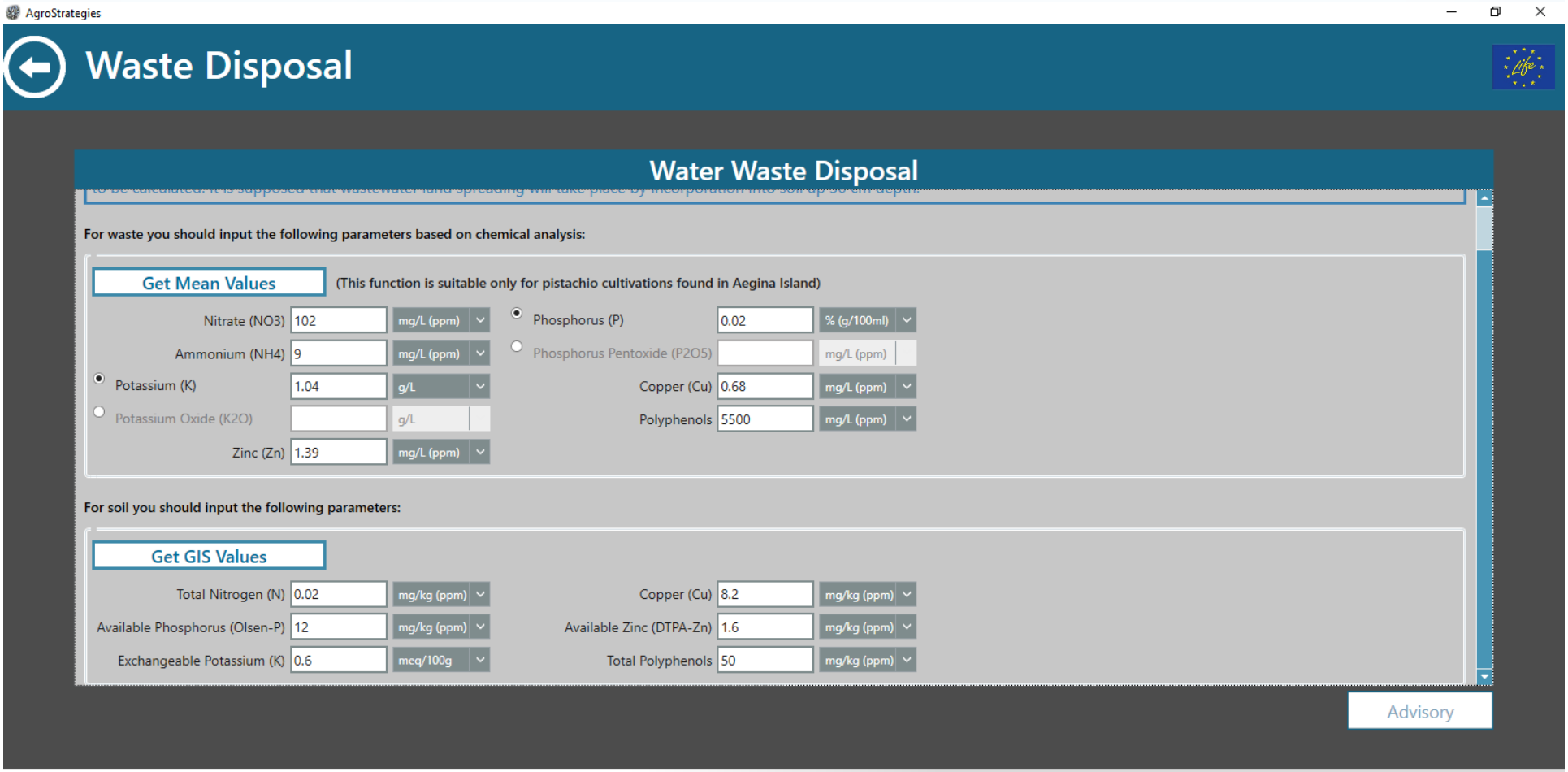
Soil sampling and soil characterization:
Dr. Sid Theocharopoulos, Chronis Kolovos (ELGO DEMETER)

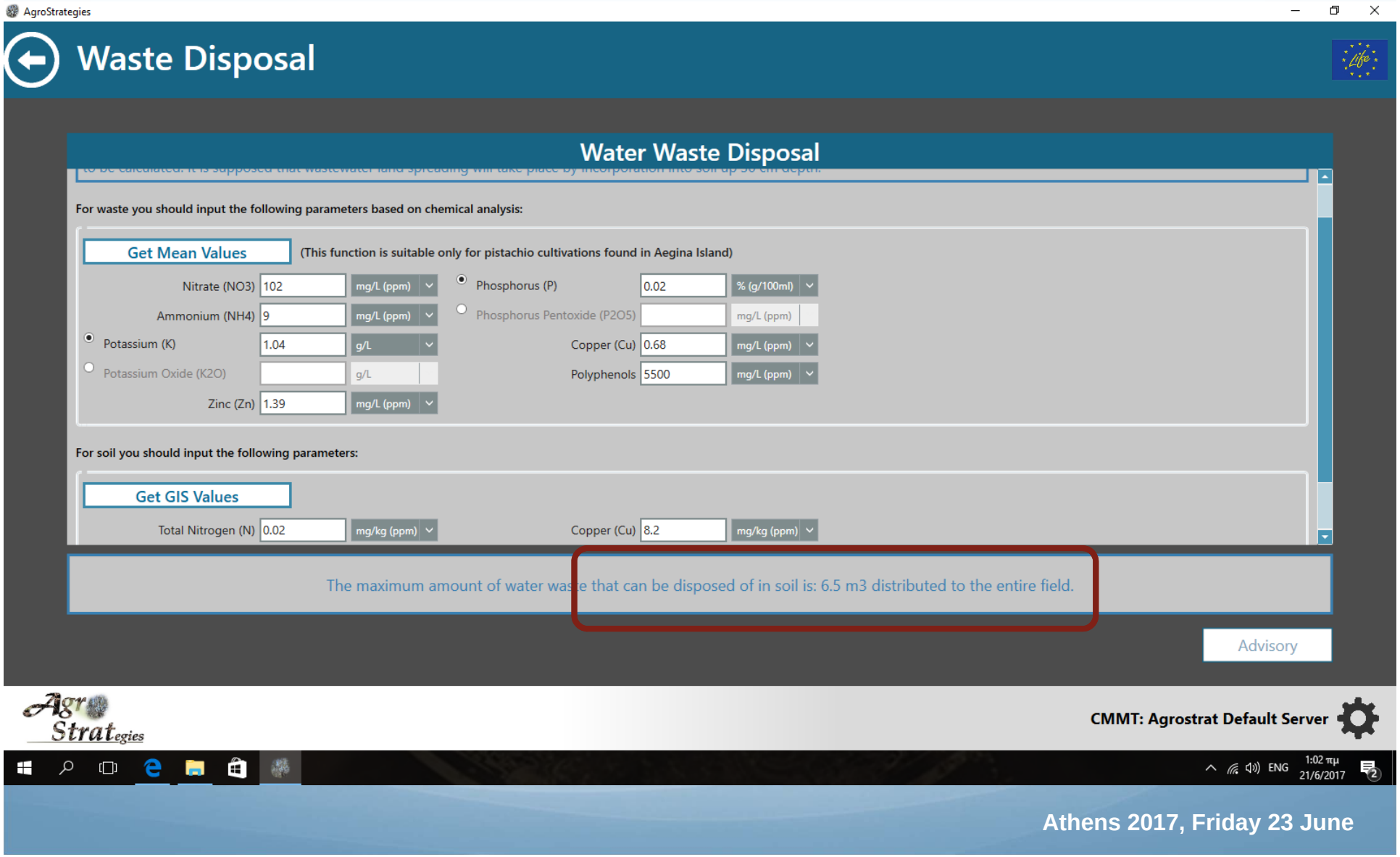

GeoSat ReSeArch
Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment
BENAKI PHYTOPATHOLOGICAL INSTITUTE
FORTH
Institute for Mediterranean Studies
AgroStrategies
Waste Disposal
Water Waste Disposal
For waste you should input the following parameters based on chemical analysis:
Get Mean Values
(This function is suitable only for pistachio cultivations found in Aegina Island)
Nitrate (NO3) 103 mg/L (ppm)
Ammonium (NH4) 9 mg/L (ppm)
Potassium (K) 1.04 g/L
Potassium Oxide (K2O) g/L
Zinc (Zn) 1.39 mg/L (ppm)
Phosphorus (P) 0.1 % (g/100ml)
Phosphorus Pentoxide (P2O5) mg/L (ppm)
Copper (Cu) 0.68 mg/L (ppm)
Polyphenols 5500 mg/L (ppm)
For soil you should input the following parameters:
Get GIS Values
Total Nitrogen (N) % (g/100g)
Available Phosphorus (Olsen-P) mg/kg (ppm)
Exchangeable Potassium (K) cmol(+)/kg
Copper (Cu) mg/kg (ppm)
Available Zinc (DTPA-Zn) mg/kg (ppm)
Total Polyphenols g/kg
Insert soil parameters
Advisory
AgroStrategies
CMMT: Agrostat Default Server
ENG
12:59 πμ
21/6/2017
Athens 2017, Friday 23 June

GeoSat ReSeArch
Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment

BENAKI PHYTOPATHOLOGICAL INSTITUTE

FORTH Institute for Mediterranean Studies




AgroStrategies
Waste Disposal
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Get Mean Values
(This function is suitable only for pistachio cultivations found in Aegina Island)
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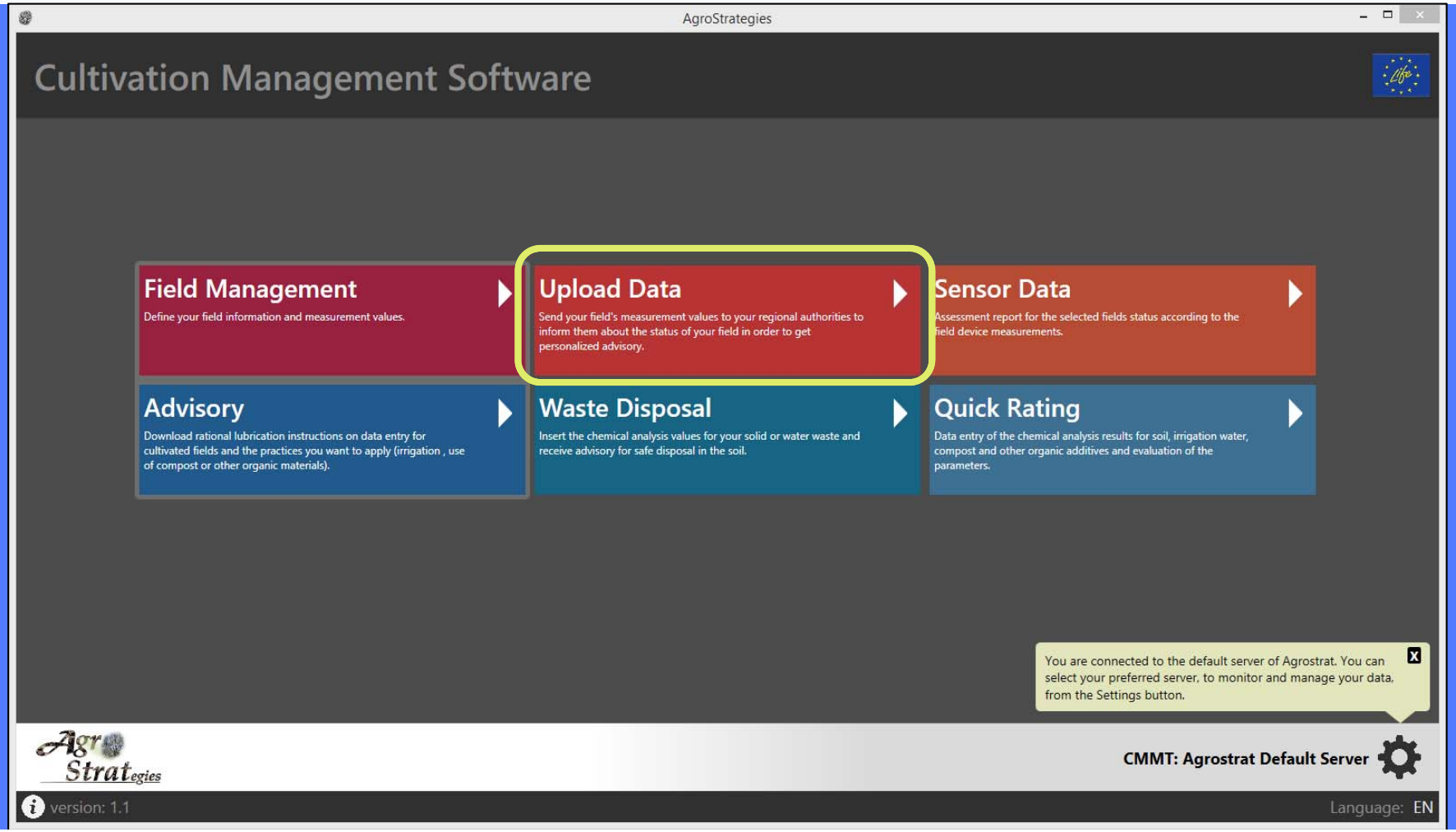
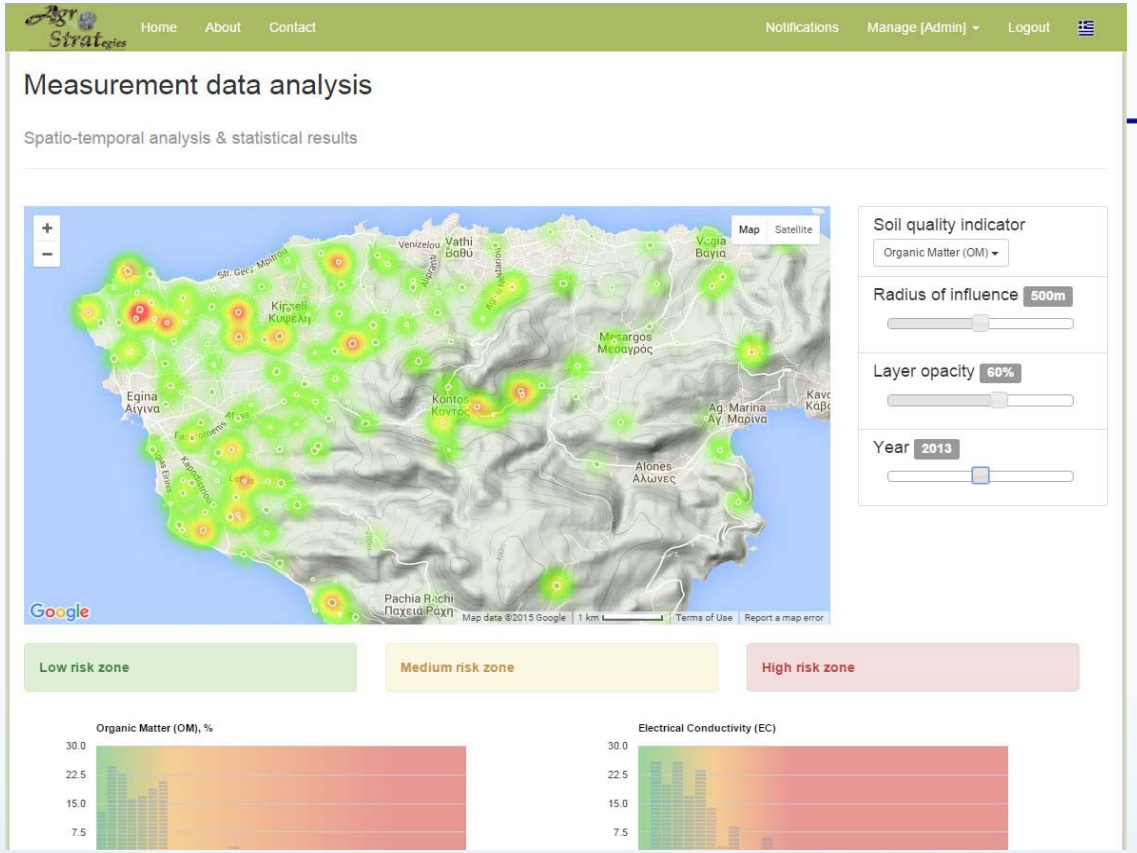
Ammonium (NH4) 9 mg/L (ppm)
Potassium (K) 1.04 g/L
Potassium Oxide (K2O) g/L
Zinc (Zn) 1.39 mg/L (ppm)
Phosphorus (P) 0.02 % (g/100ml)
Phosphorus Pentoxide (P2O5) mg/L (ppm)
Copper (Cu) 0.68 mg/L (ppm)
Polyphenols 5500 mg/L (ppm)
For soil you should input the following parameters:
Get GIS Values
Total Nitrogen (N) 0.02 mg/kg (ppm)
Copper (Cu) 8.2 mg/kg (ppm)
The maximum amount of water waste that can be disposed of in soil is: 6.5 m3 distributed to the entire field.
Advisory
CMMT: Agrostrat Default Server
ENG
1:02 πμ
21/6/2017

....and data can be sent to a Central Management Center

- Authorities can monitor soil properties
- Provide consultancy to the farmers



Monitoring of cultivated areas
A web GIS based application for soil data collection, processing and evaluation



The application provides temporal evaluation of the cultivated areas through comprehensive charts, or statistical data analysis on a spatial scale analysis, potential to visualize the analysis results and produce local/regional maps. The platform allows individual users to communicate through the "Cultivation Management Software" with the responsible local/regional authority and request directives and guidance about their cultivated fields or discharge areas.

Strategy depends upon the ability to foresee future consequences of present initiatives

Thank you

Dr. Maria K. Doula

Benaki Phytopathological Institute
Greece