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EPAnEK 2014-2020
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ΕΣΠΑ 2014-2020
ανάπτυξη - εργασία - αλληλεγγύη
Partnership Agreement
2014 - 2020

Co-financed by Greece and the European Union

GreenWaterDrone

Development and Implementation of an Innovative and Cost-effective System for the Precise & Dynamic Irrigation Scheduling and Crop Monitoring

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Project Overview

- **Drivers and Trends**: Irrigation, Smart Farming and Drones
- **GreenWaterDrone**: Innovation, Services and Architecture
- **Business Model**: Value chain, Roles and Stakeholders
- **Greek case study**: Trifylia@Messinia

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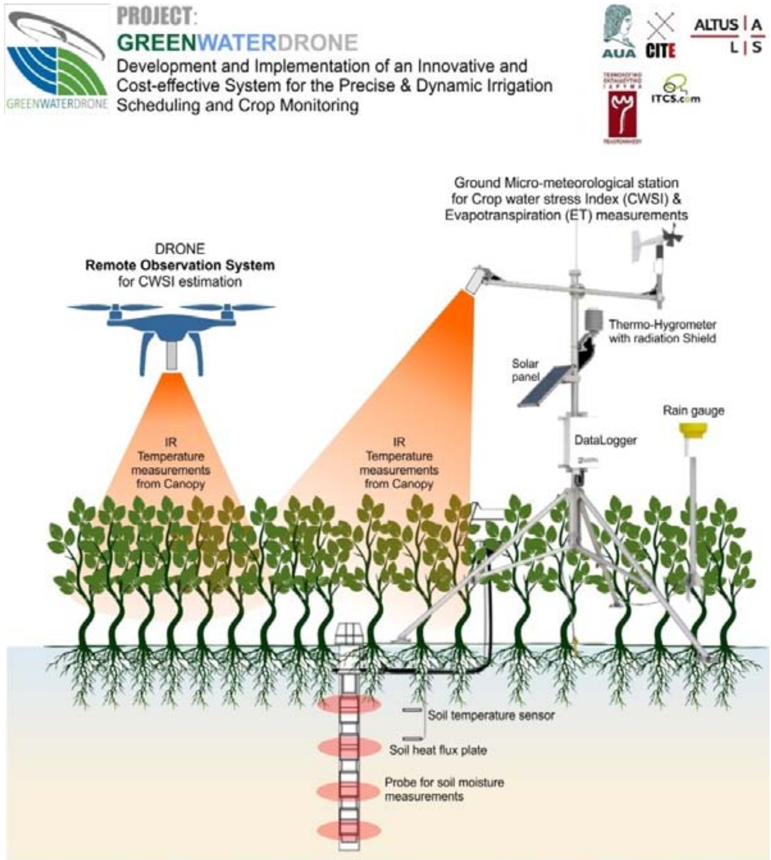


AERIAL SYSTEM

DRONE Remote Observation System for CWSI estimation for point (standing) & spatial crop measurements

-Data acquisition and recording system (Data logger)
-Sensor for High Precision Measurement of 2D Position
-Infrared Temperature sensor
-Air temperature sensor
-Air relative humidity sensor

GROUND SYSTEM

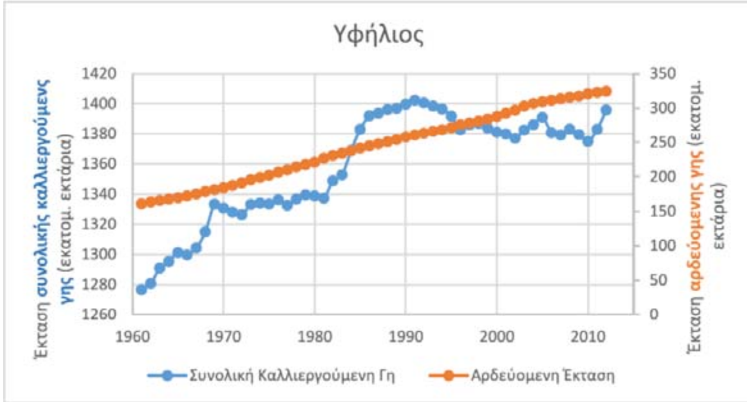
Micro-Meteorological station for CWSI calibration & Crop Evapotranspiration (Potential & Actual)

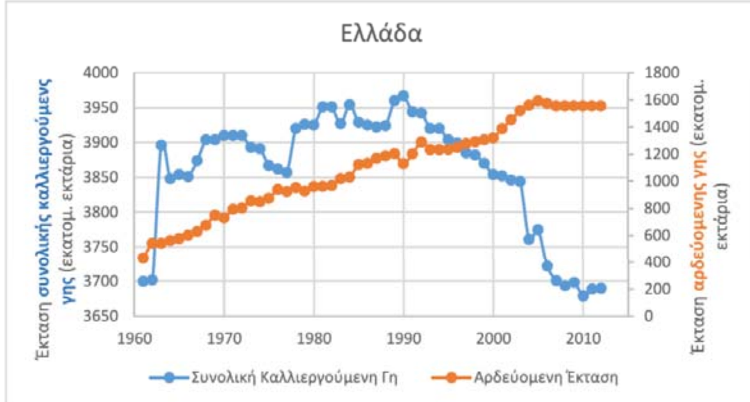
-Data acquisition and recording system (Data logger)
-Infrared Temperature sensor
-Air temperature sensor
-Air relative humidity sensor
-Data acquisition and recording system (Data logger)
-Infrared Temperature sensor
-Air temperature sensor
-Air relative humidity sensor
-Wind speed anemmeter
-Rain Gauge
-Solar incoming pyranometer
-Photosynthetic Active Rasiation (PAR)
-Net Radiation
-Soil Temperature sensor
-Soil Mosture sensor (Probe)
-Soil heat flux Plate

Ερευνώ, Δημιουργώ, Καινοτομώ

Drivers and Trends – 1: WATER

- **Agriculture: largest consumer of water** (70% globally)
- **Mediterranean basin:** Greece 88%, Spain 72%, Portugal 60%
- total **global cultivated** area (**Blue**) vs **irrigated** area (**Orange**)
- **In Greece** irrigated area increases despite the drastic decrease of cultivated land since the 1990’s [FAOSTAT]
- Dramatic increase in **water demand for domestic and industrial use** (population growth, living standards)
- **Climate change** and the alternation of **dry and humid periods**, increase complexity of water resources management
- **Salinization** of underground reservoirs by **over-pumping** through **private drilling** (much of which is illegal)
- **Nitrate pollution of agricultural origin**, mainly as a result of poor management practices
- **Water losses in the agricultural sector** are particularly high (between 60-70% worldwide and 40-60% in Greece) [HSGME]
- The **economic value of water** in the agricultural sector is much lower than in other competing sectors. The agricultural sector is in the most difficult position.





Drivers and Trends – 1++: WATER

- The estimated **surface water reserves** (rivers, lakes, and so on) and **underground reservoirs** are between **6 and 3.5 million cubic meters** respectively, as shown in the following table published by EUROSTAT,
- However, its **exploitation in our country is only 13%.**

Table 4.6.1: Groundwater and surface water abstraction, by country, 2001–13 (million m^3)

	Groundwater abstraction			Surface water abstraction		
	2001	2007	2013	2001	2007	2013
Belgium (1)	679	648	602	6 316	5 570	4 480
Bulgaria	719	642	558	5 114	5 560	4 910
Czech Republic	529	381	371	1 310	1 589	1 279
Denmark (2)	693	567	644	15	3	8
Germany (3)	6 204	5 825	5 841	31 802	26 476	27 195
Estonia	272	248	213	1 199	1 586	1 535
Ireland	:	213	:		517	:
Greece	3 390	3 651	:	6 384	5 821	:
Spain (2)	5 759	6 496	6 884	30 349	29 077	30 465
France (2)	6 284	5 662	5 608	27 261	25 748	24 400
Croatia	:	464	444			189
Italy	:	:	:			:
Cyprus	141	145	140	61	71	115

Drivers and Trends – 2: SMART Farming

- The size of **the global Precision Agriculture market** was around **3.45 billion euros** in 2018 and is expected to grow at an average Compound Annual Growth Rate **(CAGR) of 14.2% by 2025**, according to a recent study. Other reports expect a faster rate of 18% (CAGR) by 2021.

- Growth is largely attributed to the growing proliferation of **Internet of Things (IoT)** and increasing use of advanced **data analytics by farmers.**

- A number of Irrigation Water Management / Saving Technologies are employed today, a promising field being **accurate spatial and temporal estimation of crop water needs**, with remote sensing.

- **Remote sensing** is generally used in precision irrigation applications to detect aquatic stresses of plants, using the thermal infrared (TIR) or microwave portion of the foliar electromagnetic (EM) radiation.

- GreenWaterDrone applies a **combination of Infrared Thermometry and Crop Water Stress Index (CWSI)** estimation, measuring the change in foliage temperature (TIR) in relation to the transpiration rate of the plants.

- The worldwide market for **radiometric imaging systems** is expected to grow in terms of **CAGR by 9.91%** in the period 2018-2023, thus increasing the quality and reducing the cost of such systems.

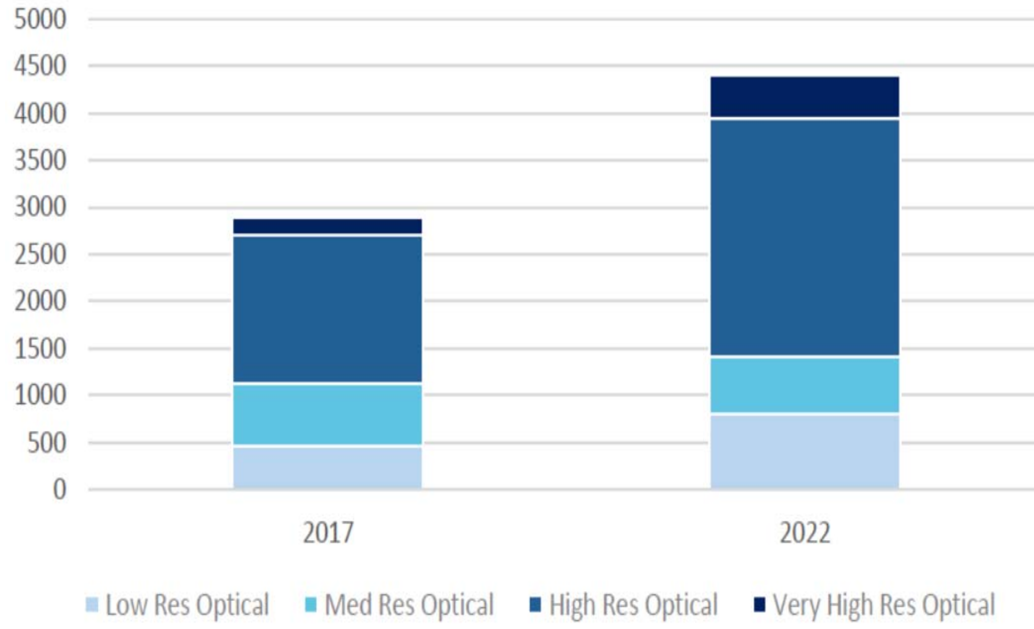
Drivers and Trends – 3: IR Thermometry

- **Remote infrared temperature measurement** of the crop foliage is carried out by installing in the field**, fixed ground infrared (IR) thermometers**, adapted to metal grids.
- The method provides **sufficient temporal resolution**, but **limited spatial resolution**
- **Spatial coverage depends on the number of installed sensors** (IR Radiometers) and does not account for the heterogeneity of the crop.
- **High cost of installation and operation** (maintenance and adjustment of equipment following plant growth)
- **Intervening nature** (permanent installation in crops, restriction of cultivation processes)
- Such system can help determine the ability to **omit irrigation in part of the crop**, either because plants are suffering from diseases, or because they have not survived in that part of the field.

Science News: "*Precision Irrigation Built into Sprinkler Booms Controls Water Usage, Optimizes Crop Growth*". US Department of Agriculture, ARS

Drivers and Trends – 4: SAT Telemetry Market

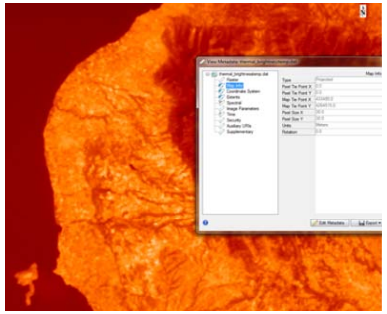
- In 2017, the **global satellite market for Earth Observation (EO)** was estimated at between 9.6 and 9.8 billion euros [Copernicus Market Report, Feb. 2019]
- EO data, **processing and transformation into end-user information products** (the “downstream” value chain segment): estimated at a range of 2.6 - 2.8 billion euros
- In the **market for data and services requiring high accuracy** (sub-metric resolution data), government customers (military and intelligence services) dominate. Commercial applications, including Precision Agriculture, currently account for 1/3 of total revenue, but with higher expected growth rates 12-16%.
- **European system Copernicus**, since 2008, for Precision Agriculture applications is one of the most dynamically evolving in Europe, with an average CAGR of 20% for intermediate users (providers of services, SMEs, Uni/s) and 31% for end users (e.g. farmers) of these services.



Global Satellite Market
for Accurate Observation Services 2017-22
[PriceWaterHouseCooper]

Drivers and Trends – 5: SAT Imagery issues

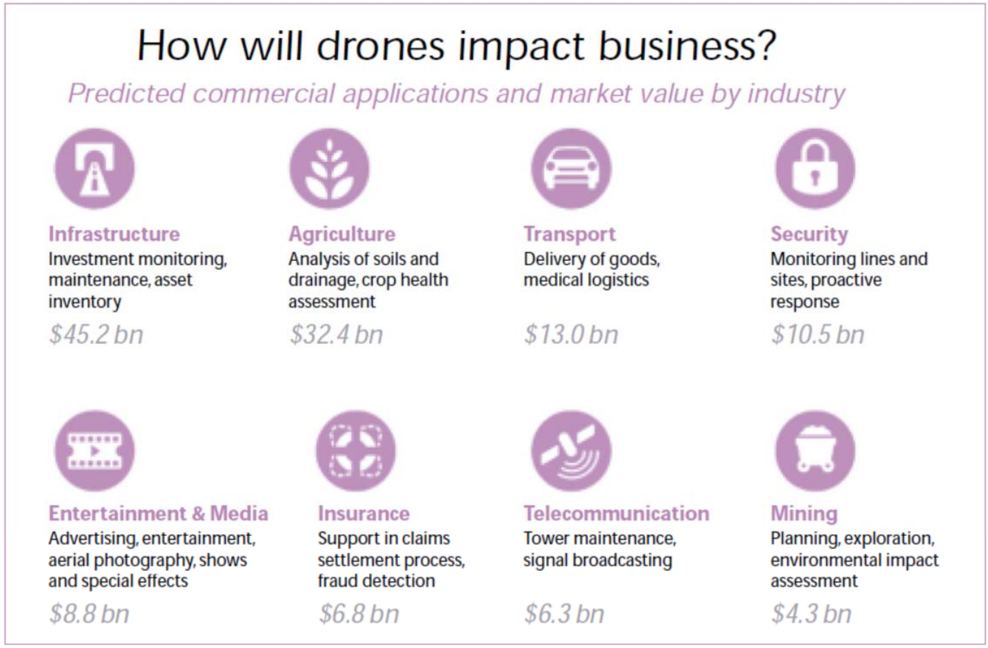
- Many satellite imagery services today are provided either **for free or at a very low cost**, as they are addressed to government and research institutions.
- Problems with applying these to methodologies and systems, which require **high spatial and temporal accuracy**:
  - Spectral analysis of such services provides **low spatial resolution** of 20-30 meters
  - Heat radiation they record in the upper layers of the atmosphere has already passed twice through it, thus **requiring further specialized processing / calibration**.
  - Images with **low temporal resolution**, i.e. a frequency of a week, or more.
  - Thermal infrared radiation **cannot penetrate clouds**, i.e. take measurement at a desired time during the growing season.
  - In areas with high heterogeneity of crops, there is increased **failure margin** (~ 60%), limiting the use of satellite methods to large-scale applications, i.e. cost management and decision-making for irrigated areas and not for detailed field-level approaches.



Real color image of Landsat 8 satellite (up) and low resolution thermal image (30m) of the same satellite (down).

Drivers and Trends – 6: Drone market

- According to a wide-ranging study of 2016, the **global drone market in the agricultural sector** is US $ 32.4 billion in 2016-17, as shown in the figure.
- An analysis by the Association for Unmanned Vehicle Systems International predicts that the global **market share of drones, occupied by agricultural applications will be 80% by 2025**.
- Major applications include spraying, crop scouting, field mapping, monitoring, planting, irrigation, plant health assessment, and more.
- Agricultural drones are expected [IPSOS] in the coming years to **improve productivity by 40 to 60 times** in relation to manual labor and up to 5 times faster than using a tractor.
- At European level, the drone industry is expected to employ more than 100,000 people by 2035, with the financial impact exceeding € 10 billion per year.

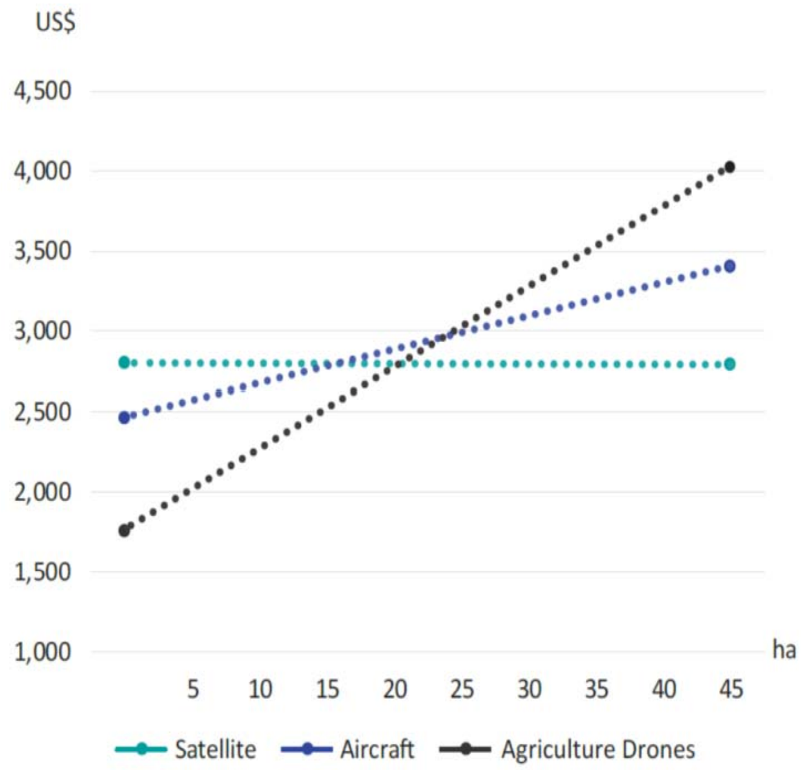


Global Drone Market per sector 2016-17 [PriceWaterhouseCooper]

Drivers and Trends – 7: Drones vs Satellites

The use of drones for thermal imaging has significant advantages over corresponding applications of satellite systems:

- Agricultural drones provide low cost images with **high spatial resolution up to a few centimeters**. Corresponding satellite services have a fixed cost, which is becoming competitive for areas of more than 20 hectares. Drones also provide **less aerial nuisance**, compared to manned aerial vehicles (aircraft).
- Drones are not affected by **cloud coverage**, and can dynamically **adjust their image capture times**, ultimately providing better time resolution and greater adaptability to users' needs.
- They **combine different capture technologies in the same flight** (eg InfraRed, Multi-Spectral) with real-time feedback, allowing for simultaneous management of different field zones, heterogeneous crops and applications.
- Drones do not tolerate the **influence of the atmosphere** as they hover at low altitudes, collecting high-resolution data.



Cost Comparison of Imaging Technologies [IPSOS Business Consulting]

GreenWaterDrone: innovation

- Main innovative features and capabilities of the system:

- No thermographic camera is used for temperature measurement, but a **lightweight and low-cost Infrared (IR) sensor** which instantly records measurements in a data logger, improving accuracy, processing time per measurement and overall cost.

- This sensor is identical to the terrestrial micro-meteorological station (MMS) sensor used to calibrate the CWSI for each crop, ensuring **consistency of measurements**.

- The Drone also has additional temperature and relative humidity micro-sensors and a high-precision GPS receiver to collect and map all required microclimate parameters above the crop, at any spatial point of the area under consideration, **even at plant level**, for **accuracy in estimating CWSI**.

- The drone can hover a few meters above the foliage, in a stable spatial position for a short time, making **focused repetitive measurements** possible. Capture is guided by a visual surveillance system to minimize failure (relative to the density of the crop and soil coverage).

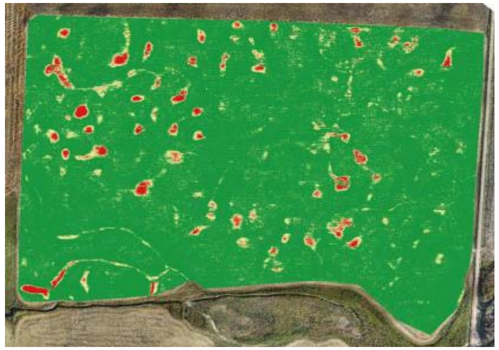
- **Single flight for heterogeneous vegetation**, by recording the spatial coordinates of each set of measurements, so that different crops can be monitored simultaneously in the covered area.

GreenWaterDrone: Services

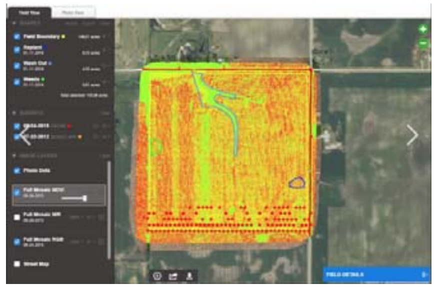
- Main features and capabilities of the system corresponding to services:

Irrigation Alerting & Scheduling: Temperature measurements are recorded in real time in a DB and are combined with micrometeorological data and calibration data from the MMS (needed only during the calibration stage), to calculate CWSI and immediate notification of the need for irrigation. **The end-user is dynamically alerted (desktop / mobile) to the need for irrigation.** The alert can be translated into an existing irrigation system with spatial resolution corresponding to its capabilities.

Crop Surveillance: the end-user can view **on-demand crop snapshots**, in real-time (e.g. physical or other disasters, or regular surveillance flights), or asynchronous, i.e. snapshots stored at regular times of his choice. Choice between **optical and other** (e.g. thermographic) images from the relevant Database. There is also the possibility of **photogrammetry** (crop field mapping for height estimation and plant growth monitoring).

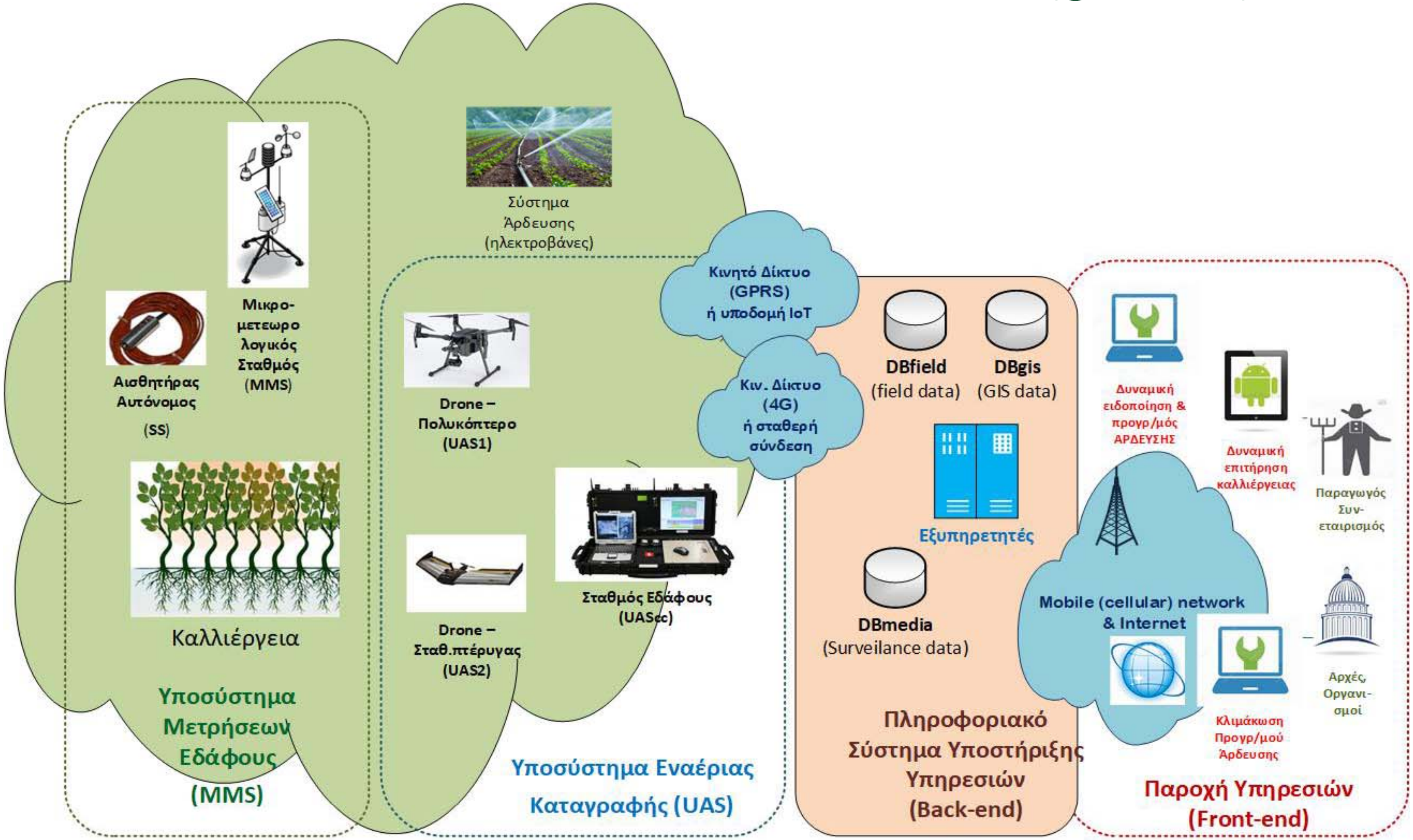


Irrigation Water Management: On a graphical environment with a map of a zone covered by the system, the user may **define areas and obtain irrigation needs for a specific period and type of crop, or crop mix.**

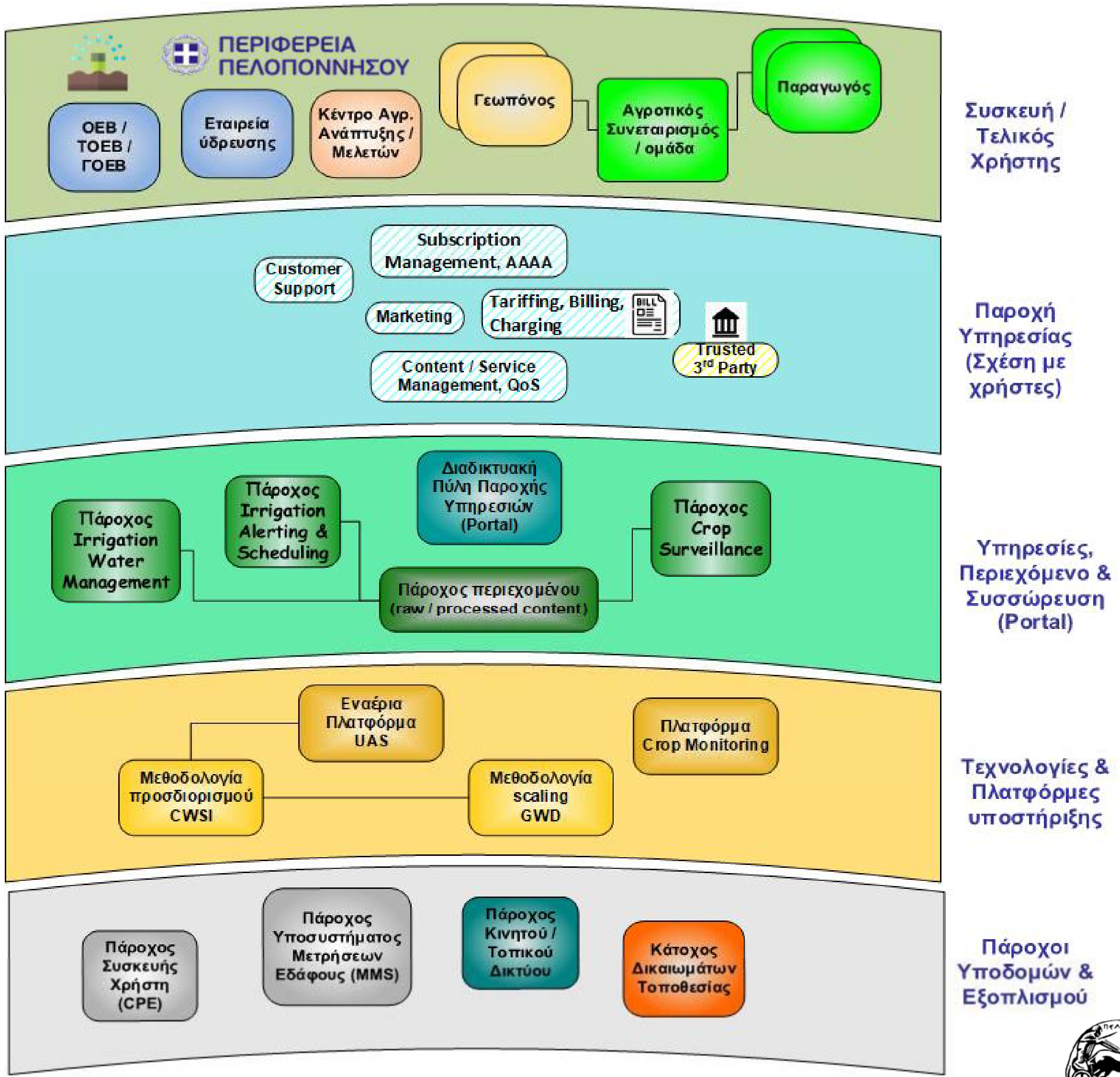


A prerequisite for reliable service provision is the adequate recording of sample calibrations of representative crops in the area (i.e. operation of the system in the area) and the availability of historical local meteorological data.

GreenWaterDrone: Functional Architecture (generic)



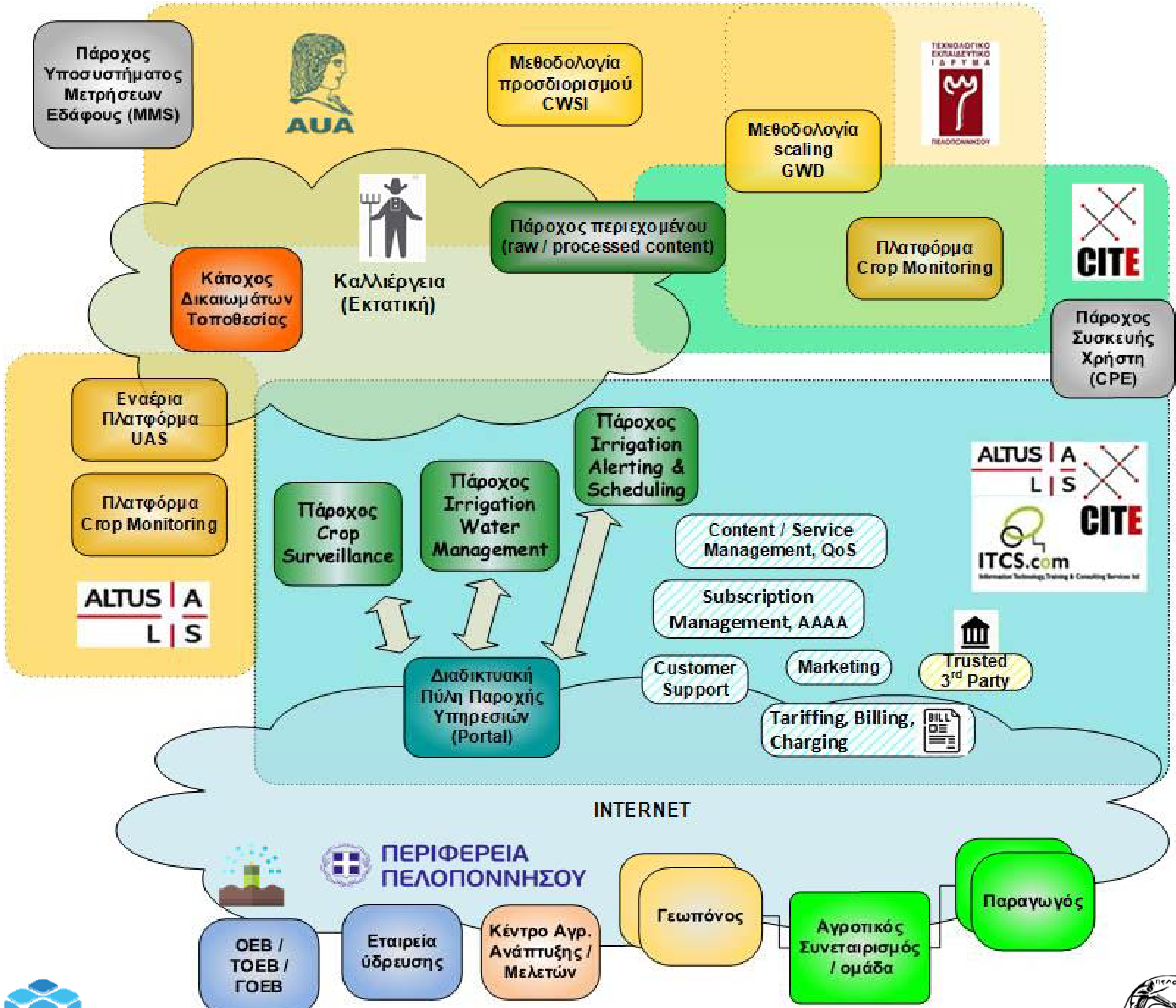
GreenWaterDrone: Value Chain (roles in layers)



GREENWATERDRONE

SEEDA-CECNSM CONFERENCE 2019 20-22 September | Piraeus, Greece

GreenWaterDrone: Business Model (generic)



Greek case study – 1: Trifylia

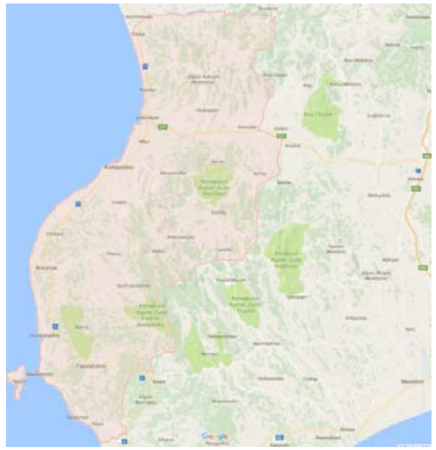
- An area was required for pilot implementation, combining specific qualitative and quantitative features, both in terms of field / crop characteristics and local economy.

- **Vegetables is perhaps the most dynamic sector of Greek agriculture**, in terms of volume of production, marketing, human resources, exports and coverage of almost all domestic needs in related products. The gross income from these crops is one of the highest on farms in Greece.

- Messinia and especially the **Province of Trifylia** (see picture) is the largest outdoor and greenhouse vegetable production center in Greece after Crete. The special, **mild microclimate and the sandy soils** provide high quality products. It supports about 3,000 acres of crops and total production reaches 80,000 tons per year, from 2 growing seasons (early - late).

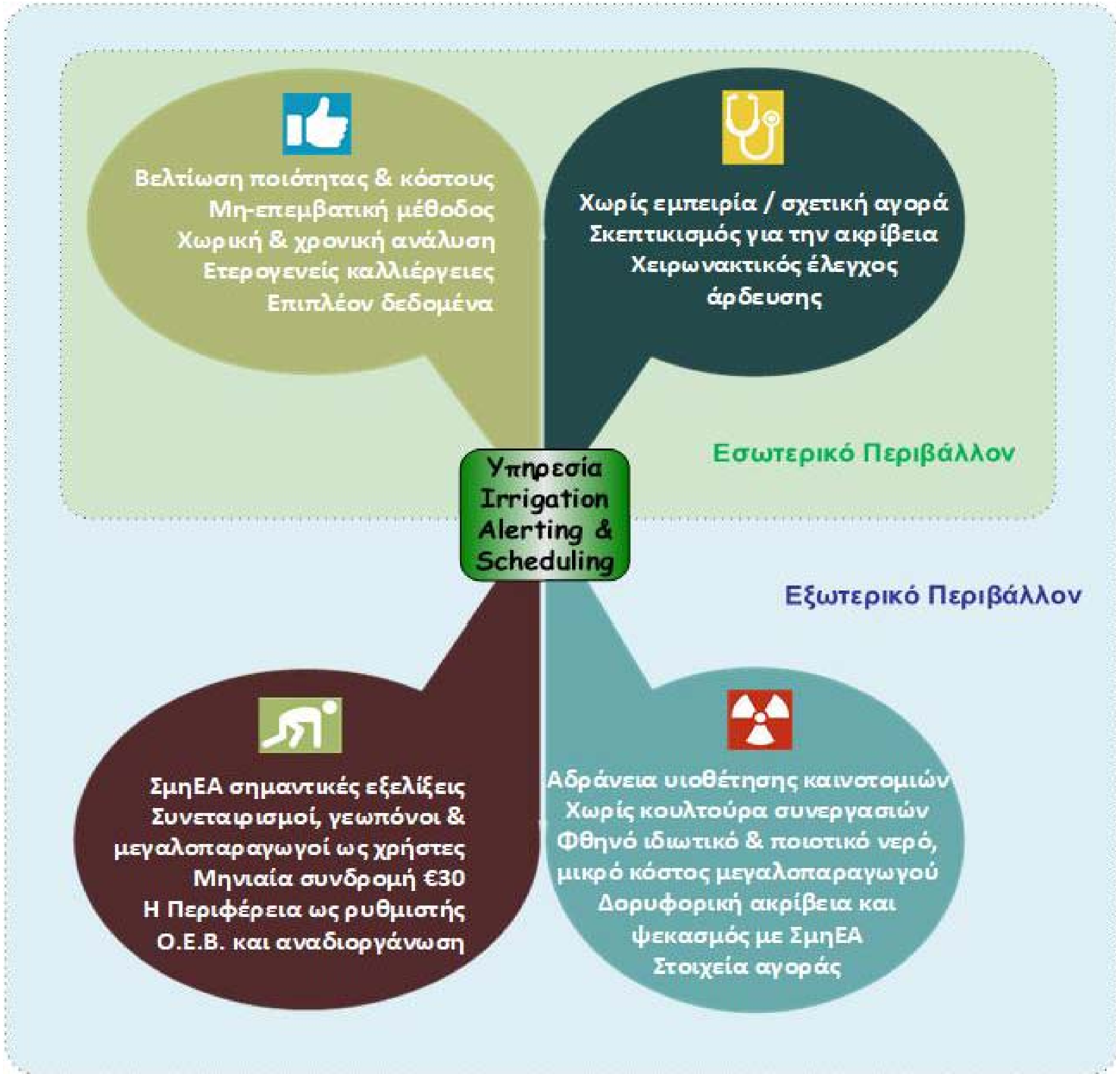
- **Producers in Trifylia** (original target group 40-50) have the specific features that ensure efficient implementation of the system and services, such as **large-scale** (100-300 acre) **outdoor** and **heterogeneous** crops (justifying UAV flights) that are **privately owned** (> 70%), high volume and quality of production (**exports in 24 countries, annual turnovers of 100K € -500K €**), highlighting the benefits of services and ensuring early adoption.

- **Local regional authorities** have shown increased interest and cooperation, both during the preparation phase and implementation, marking their intention to utilize the project as a **tool for developing water policies and strategic decision-making for integrated irrigation water management** at national level.

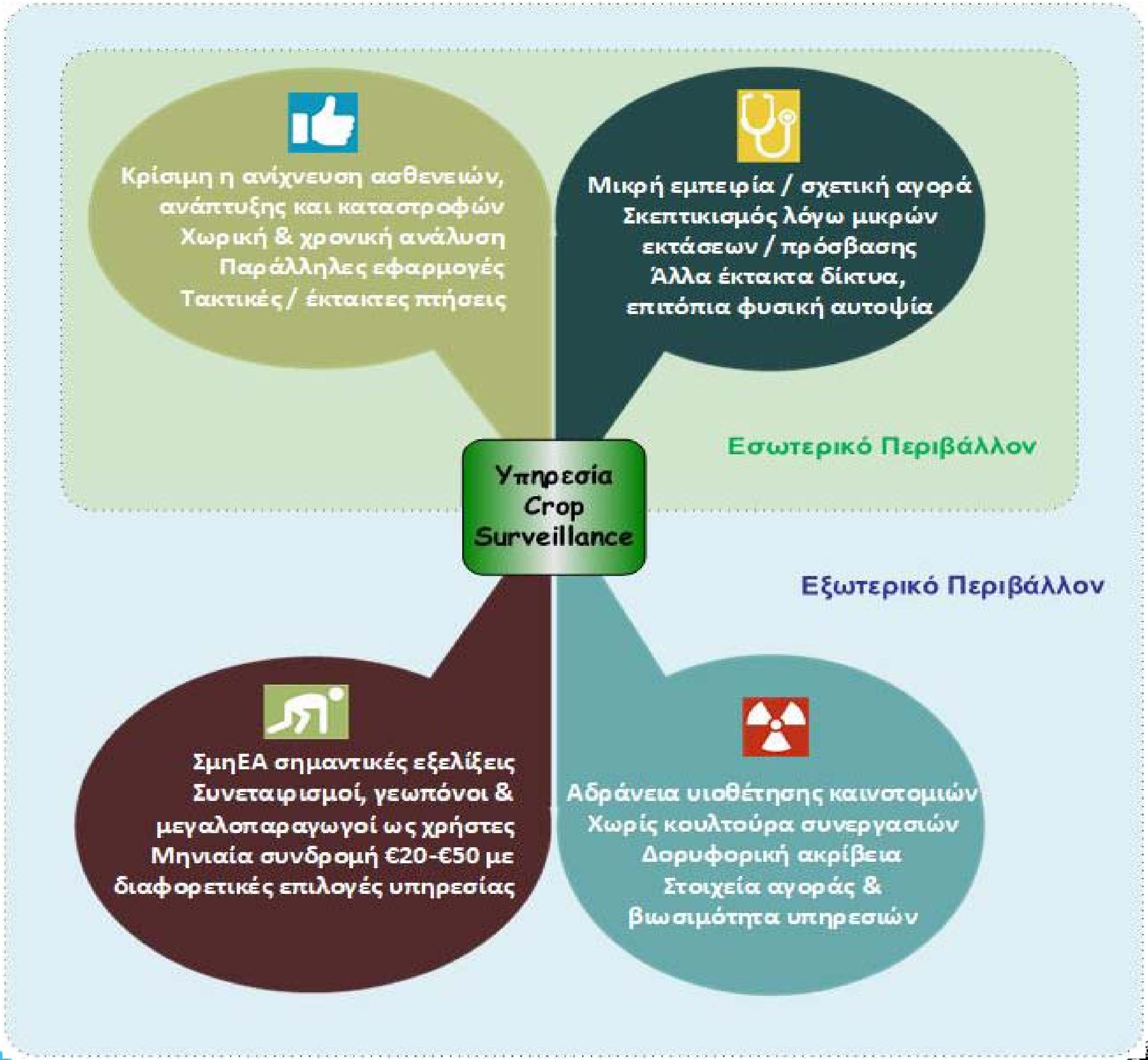


Province of Trifylia in Messinia, Peloponnese

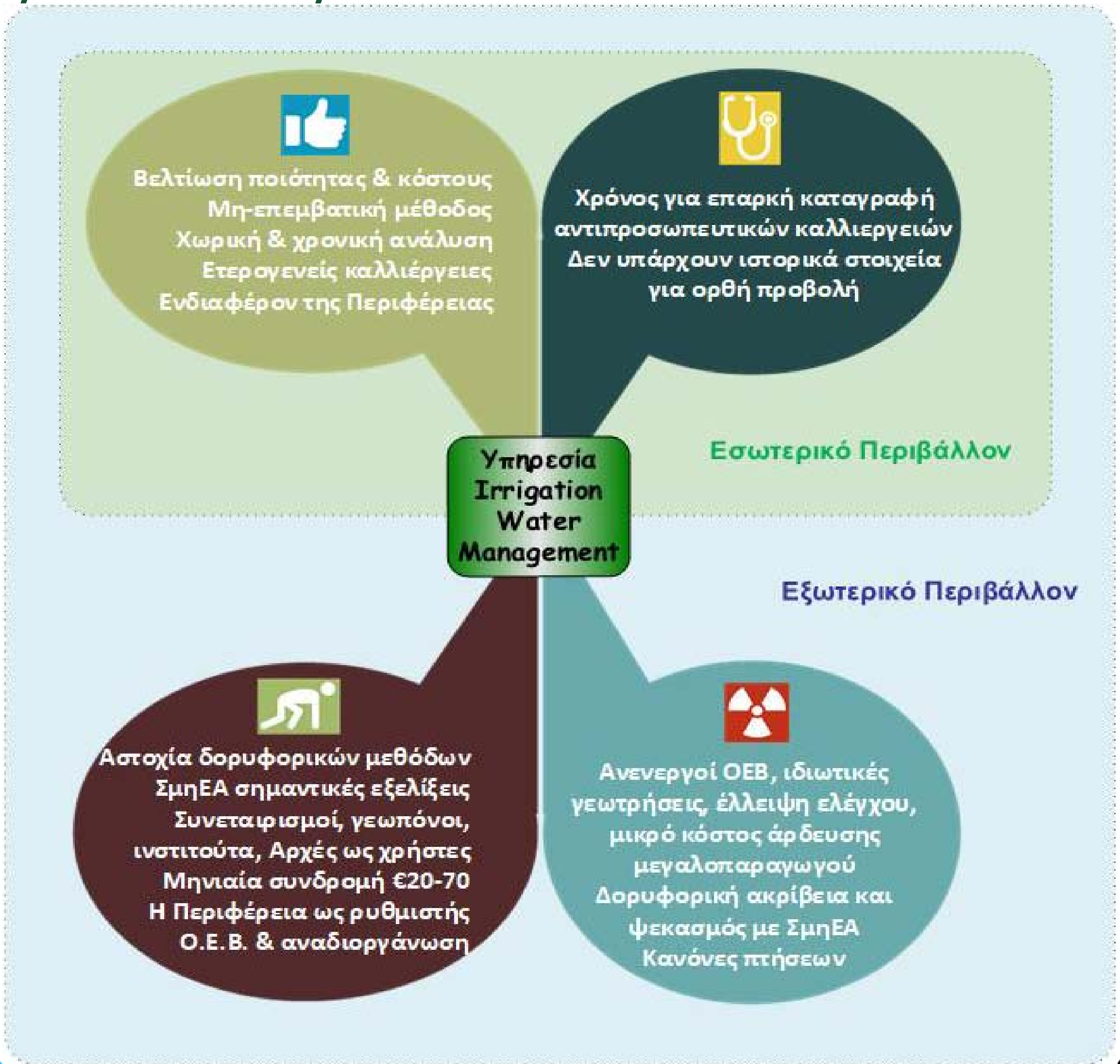
Greek case study – 2: surveys & SWOT



Greek case study – 3: surveys & SWOT



Greek case study – 4: surveys & SWOT



Greek case study – 5: user surveys & MMS installations on site

Thank you!

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