

**Project:**  
**ENORASIS**  
**(Grant Agreement 282949)**

“ENVIRONMENTAL OPTIMIZATION OF IRRIGATION MANAGEMENT WITH THE COMBINED USE AND INTEGRATION OF HIGH PRECISION SATELLITE DATA, ADVANCED MODELING, PROCESS CONTROL AND BUSINESS INNOVATION”

Funding Scheme: Collaborative Project  
 Theme: FP7-ENV

**D6.1: Pilot Implementation Guidelines**

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<b>Issue date:</b>	24/10/2012
<b>Due date:</b>	01/01/2014
<b>Work Package Leader:</b>	INSTYTUT UPRAWY NAWOZENIA I GLEBOZNAWSTWA, PANSTWOWY INSTYTUT BADAWCZY

Start date of project: 01 January, 2012

Duration: 36 months

<b>Document History</b> (Revisions – Amendments)	
<b>Version and date</b>	<b>Changes</b>
0.1 1 01.10.2012	Creation of the table of contents' draft. M. Matyka
1 24.10.2012	Guidelines draft. M. Matyka, J. Niedźwiecki, J. Kozyra, R. Wawer
2 30.10.2012	Changes in the document structure. R. Wawer, Jerzy Kozyra
3 8.11.2012	Incorporating agreements from the meeting in Novi Sad. R. Wawer
4 15.11.2012	Adding chapter on soil surveying and sampling. J. Niedzwiecki
5 21.11.2012	Final draft. M. Matyka
6 3.12.2012	Editorial. M. Matyka
7 10.02.2013	Methodology for yield sampling updated. M. Matyka
8 6.02.2013	Progress reporting templates added.
9 3.12.2013	Draft for the 2014 season considering the feedback from partners running pilots during 2013 season
10 23.12.2013	Final version. Updating methodologies for farm pilots in Cyprus and Serbia. Adding new chapter on hardware control and maintenance.

**Dissemination Level**

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**Statement of originality:**

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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## EXECUTIVE SUMMARY

The deliverable D6.1 "Guidelines for Pilot Implementation" aim at laying the consistent rules for the testing of ENORASIS platform in real-life conditions on 5 testing sites across 4 latitudinal zones – ENORASIS pilots. The pilots are divided into two groups: research pilots, where strict scientific experiments are conducted to validate the system's algorithms and its internal connectivity; farm pilots, serving two goals: demonstration of ENORASIS' capabilities in real farming application as well as testing the system behaviour under different real life cases.

The guidelines contain rules for conducting the experiments, setting up the hardware on the field, determining the soil texture and delineating irrigation plots on the field. It also includes the set of Key Performance Indicators, that will be used in order to test the ENORASIS system.

## 1. INTRODUCTION

The two core aims of ENORASIS pilots are to cover an adequate spectrum of different real-life cases and to effectively incorporate in its pilots the main needs and requirements of its target groups' (farmers, water management organisations) thus, be able to properly validate and assess ENORASIS system capability to successfully meet them. More specifically, ENORASIS Pilots will involve 7 crop types in four different climate regimes (North Central Europe-Poland, South Central Europe-Serbia, continental Mediterranean-Turkey, island Mediterranean Cyprus).

Three kind of pilot application schemes will be developed, aimed at reaching two main goals: assessment of the ENORASIS system's suitability for target end users and the validation of system's setup. The pilots will fulfil the requirements of wide geographical coverage, minimal spectrum of representative crops and different operational approaches plus undertake the economical analysis of the irrigation effect on crop production. The schemes will assure homogeneity (where possible) of the pilot applications to allow later comparisons and to assure interoperability at system level.

Pilot implementations include the setup of the ENORASIS test-bed environment for the 4 pilots as well as the detailed definition of the Key Performance Indicators (KPIs) upon which will take place the monitoring, measurement, validation and assessment of the ENORASIS System and Components. In all pilots a similar approach is followed. Deployment includes the adaptation of the ENORASIS prototype and installation of the related infrastructure at the deployment sites, based on the prescribed usage scenarios as these will be detailed in the course of Task 6.1. The fields in the pilot locations will be equipped, where necessary, with irrigation devices (e.g. research farm in Poland). In addition, stationary ENORASIS system hardware components (e.g. wireless sensor networks and smart cards systems) will be deployed too.

In each pilot case, the required field measurements (e.g. crop growth ratios, final crop yields, etc) will be implemented by the consortium following standards as well as requirements deriving from Key Performance Indicators. In particular for the case of the research farm a no-irrigated zero-measurement fields experiments will be conducted to be used as reference.

At process / technical level, important implementation related issues will be tackled, e.g.: platform compatibility with the existing process-related capabilities existent at the levels of the User partners. It is at this point that the issue of ENORASIS process integration and business process interoperability (at all three levels of data, system and service) is considered. Finally, all measurements as well as feedback gathered from involved actors will be used to highlight potential pain areas as well as areas for improvement, at field, process and ICT technical level triggering (in task 6.3) the implementation of the appropriate modifications on ENORASIS components and system by the project technical partners.

The effectiveness of the ENORASIS irrigation control will be assessed during two-season long experiments on pilot areas / fields. Original one-season approach (as described in project's DoW) has been changed to two-season to reduce the risk of testing as irrigation system in a wet season. An extensive economic analysis will be performed based on pilot ENORASIS implementations by taking into account KPIs defined at task 6.1. The results will be compared with crop yields achieved by end users utilizing other irrigation management methods and systems or growing crops without irrigation, if available. The ENORASIS system will be refined based upon the real-life system run experiences gained from pilot applications.

Finally, besides the demonstration of the ENORASIS prototype for validation, assessment and thus, potential improvement purposes, pilots will also target to prove the feasibility of the uptakes scenarios of the whole ENORASIS solution at different operational settings and contexts. As a result, the assessment of pilots is also expected to provide valuable quantitative as well as qualitative proofs on the concept, business model(s) and on the operational capabilities of ENORASIS solution, revealing also additional enhancements and optimisations required (to be implemented after project completion) so as to be transformed from a system prototype to a commercialised final product – 'The ENORASIS Service Platform'. Those aspects are particularly important for and expected to feed both the 'Exploitation and Sustainability Plan.

Summarizing, the objectives of the ENORASIS pilots are following:

- To define in the detail the pilots' context as well as the concrete validation criteria & success measures (Key Performance Indicators - KPIs).
- To involve end users (farmers, water management organisations) in pilot preparation and execution.
- To setup the ENORASIS test-bed environment in real life conditions
- To implement the pilots so as to cover several (at least 5) crops types, multiple (4) geographical areas of different climate characteristics, and different (3) operational settings.
- To validate & assess ENORASIS solution against specified Key Performance Indicators (KPIs).

## 2. PILOT LOCATIONS

The pilot application schemes will be applied in chosen locations in Poland, Serbia, Turkey and Cyprus. More specifically, for Pilot 1 it will be used the research farm of IUNG-PIB in Poland. Pilot 2, which has as a focus area the operational context of water management organisations, the water management organisation of Serbia (VoVo), whereas production farms required will be easily attracted by utilising both water authority's excellent contacts with farmers as well as the contacts of the leading Institute in Serbia, FTS, which is also ENORASIS partner. Similarly, clients (production farms) of TEKNOSET in Turkey and Cyl in Cyprus are also expected to be involved in the pilots 3 and 4 (table 1). Thanks to the cooperation between TEKNOSET and Adnan Menderes University, Faculty of Agriculture, the Turkish pilot has been reorganized from a farm pilot to a full research experiment.

**Table 1. Localization and main characteristics of pilots**

Specification	Pilot 1		Pilot 2	Pilot 3		Pilot 4		Pilot 5
Country	Poland			Serbia		Turkey		Cyprus
Plots	1	2	3	1	2	1	2	1
Crop type	Potato	Maize	Potato	Apple (Breaburn)	Sweet Cherry (Burlat)	Corn	Cotton	Grapefruit
Farm name	Grabów ES		Farm Frites 2	Podunavlje" d.o.o., Čelarevo		Ayidn		Fassouri Plantations
Geographical coordinates (latitude)	51,3561		54 31 32	45,3097		37,7601		34,63
Geographical coordinates (longitude)	21,6625		17 20 09	19,4938		27,7597		32,95
Type of experiment	Research farm		Production farm	Production farm		Research farm		Production farm

\* TZARI : Transactional Zone of Agricultural Research Institute

All the localization are fully equipped with measuring and steering devices to conduct the pilot experiments.

**Table 2. Equipment of planned pilots**

Specification	Pilot 1	Pilot 2	Pilot 3	Pilot 4
Country	Poland	Serbia	Turkey	Cyprus
Water meters on farm	Yes	Yes	Yes	Yes
Water meters on each irrigation line	Yes*	Planned	Yes	Yes
Air temperature and humidity sensors (data available on-line)	Yes	Yes	Yes	Yes
Radiation sensor (data available on-line)	Yes	No	Yes	No
Rain gauge (data available on-line)	Yes	Yes	Yes	Yes
Number of soil moisture sensors (SMS) needed for ENORASIS pilot	9	6	9	5



## 3. METHODOLOGICAL APPROACH

### 3.1 Instruction for delineating irrigation plots

#### 3.1.1 Key to identification of soil texture

Soil Texture, or size distribution of mineral particles, is one of the most important measures of a soil because finely divided soil particles have much greater surface area per unit mass or volume than do coarse particles. Thus, a small amount of fine clay and silt will be much more important in chemical reactions, release of nutrient elements, retention of soil moisture, etc., than a large volume of coarse gravel or sand.

Soil (mineral) particles are broadly segregated into three size classes (1) sand - individual particles visible with the naked eye, (2) silt - visible with a light-microscope, and (3) clay - some may not be visible with a light-microscope, especially the colloidal size (i.e., < 1 micrometer or 0.001 millimeter). These sand, silt and clay groups are commonly referred to as the soil separates; soil texture is defined as the relative proportions of each class.

Soil content of fine particle sizes is so important in determining the fertility and water-supplying capacity as well as tillage characteristics of soils that it is used as one of the primary descriptive characteristics for classifying soil horizons and soil profiles. The U.S. Department of Agriculture soil textural classes are shown on the soil texture triangle

Commonly used methods to determine soil texture include:

- Field Procedure
- Laboratory Procedure:
  - Hydrometer method
  - Sieve method
  - Pipette method

Soil texture is a qualitative classification tool used in both the field and laboratory to determine classes for agricultural soils based on their physical texture. The classes are distinguished in the field by the 'textural feel' which can be further clarified by separating the relative proportions of sand, silt and clay using grading sieves: The Particle Size Distribution (PSD). The class is then used to determine crop suitability and to approximate the soils responses to environmental and management conditions such as drought or calcium (lime) requirements. A qualitative rather than a quantitative tool it is a fast, simple and effective means to assess the soils physical characteristics. Although the U.S.D.A. system uses 12 classes.

Soil separates are specific ranges of particle sizes. In the United States, the smallest particles are clay particles and are classified by the USDA as having diameters of less than 0.002 mm. The next smallest particles are silt particles and have diameters between 0.002 mm and 0.05 mm. The largest particles are sand particles and are larger than 0.05 mm in diameter. Furthermore, large sand particles can be described as coarse, intermediate as medium, and the smaller as fine.

**Table 3. USDA soil grain size texture thresholds**

<i>Name of soil separate</i>	<i>Diameter limits (mm) (USDA classification)</i>
Clay	less than 0.002
Silt	0.002–0.05
Very fine sand	0.05–0.10
Fine sand	0.10–0.25
Medium sand	0.25–0.50

Coarse sand	0.50–1.00
Very coarse sand	1.00–2.00

Hand feel analysis, whilst an arbitrary technique, is an extremely simple and effective means to rapidly assess and classify a soil's physical condition. Correctly executed the procedure allows for rapid and frequent assessment of soil characteristics with little or no equipment. It is thus an extremely useful tool for identifying spatial variation both within and between plots (fields) as well as identifying progressive changes and boundaries between soil classes and orders.

The method involves taking a small sample of soil, sufficient to roll into a ball of approx 2.5 cm diameter, from just below the surface. Using a small drop of water or 'spit' the sample is then moisten to the sticky point (the point at which it begins to adhere to the finger). The USDA adopted its own system in 1938, and the FAO used the USDA system in the FAO-UNESCO world soil map and recommended its use. The detailed guide to field identification of soil texture by feel is to be found on a video provided by UC Davis IPO: <http://www.youtube.com/watch?v=GWZwbVJCNe>

**Table 4. USDL Field Method of Identification of Soil Texture**

Construction Outreach Program	Safety and Health	U.S. Department of Labor OSHA Office of Training and Education May 1996
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Field Method for Identification of Soil Texture				
Soil Texture	Visual Detection of Particle Size and General Appearance of the Soil	Squeezed in hand and pressure released		Soil ribboned between thumb and finger when moist
		When air dry	When Moist	
<b>Sand</b>	Soil has a granular appearance in which the individual grain sizes can be detected. It is free-flowing when in a dry condition.	Will not form a cast and will fall apart when pressure is released.	Forms a cast which will crumble when lightly touched.	Can not be ribboned.
<b>Sandy Loam</b>	Essentially a granular soil with sufficient silt and clay to make it somewhat coherent. Sand characteristics predominate.	Forms a cast which readily falls apart when lightly touched.	Forms a cast which will bear careful handling without breaking.	Can not be ribboned.
<b>Loam</b>	A uniform mixture of sand, silt and clay. Grading of sand fraction quite uniform from coarse to fine. It is mellow, has somewhat gritty feel, yet is fairly smooth and slightly plastic.	Forms a cast which will bear careful handling without breaking.	Forms a cast which can be handled freely without breaking.	Can not be ribboned.
<b>Silt Loam</b>	Contains a moderate amount of the finer grades of sand and only a small amount of clay. Over half of the particles are silt. When dry it may appear quite cloddy which readily can be broken and pulverized to a powder.	Forms a cast which can be freely handled. Pulverized it has a soft flourlike feel.	Forms a cast which can be freely handled. When wet, soil runs together and puddles.	It will not ribbon but it has a broken appearance, feels smooth and may be slightly plastic.
<b>Silt</b>	Contains over 80% of silt particles with very little fine sand and clay. When dry, it may be cloddy, readily pulverizes to powder with a soft flourlike feel.	Forms a cast which can be handled without breaking.	Forms a cast which can freely be handled. When wet, it readily puddles.	It has a tendency to ribbon with a broken appearance, feels smooth.
<b>Clay Loam</b>	Fine textured soil breaks into very hard lumps when dry. Contains more clay than silt loam. Resembles clay in	Forms a cast which can be freely handled	Forms a cast which can be handled freely without	Forms a thin ribbon which readily breaks, barely sustaining its



	a dry condition; identification is made on physical behavior of moist soil.	without breaking.	breaking. It can be worked into a dense mass.	own weight.
<b>Clay</b>	Fine textured soil breaks into very hard lumps when dry. Difficult to pulverize into a soft flourlike powder when dry. Identification based on cohesive properties of the moist soil.	Forms a cast which can be freely handled without breaking.	Forms a cast which can be handled freely without breaking.	Forms long, thin flexible ribbons. Can be worked into a dense, compact mass. Considerable plasticity.
<b>Organic Soils</b>	Identification based on the high organic content. Muck consists of thoroughly decomposed organic material with considerable amount of mineral soil finely divided with some fibrous remains. When considerable fibrous material is present, it may be classified as peat. The plant remains or sometimes the woody structure can easily be recognized. Soil color ranges from brown to black. They occur in lowlands, in swamps or swales. They have high shrinkage upon drying.			

**3.1.2 Soil Sampling Designs**

The accuracy of soil analyses and the subsequent interpretation of test results depends on various factors: how the soil samples were collected in the field, how they were handled and how they were processed during the analysis. In collecting soil samples we have to remember that soil characteristics vary even in a small piece of land. Their texture and chemical composition depends on different factors. Therefore we have to divide the area into small units and collect sufficient samples to represent the whole area. The size of a sampling unit is often decided by various factors, such as the differences in soil color or texture, slopes and/or drainage characteristics, the previous use of the land for cropping and the consideration of uneven growth areas.

There are two different methods for sampling. The first sampling method is performed at a fixed depth while the second sampling technique is taken from each horizon. The specific method and processing strategies of the sampling collection are indicated in the soil sampling design. The designer should have a simple map of the area; it does not to be exact – a rough sketch will do. First, one must indicate on the map the number of sampling areas, selected on the basis of uniformity of size and type of important in order to achieve the objective as well as factual information about this part of the farm.

After this division of land, one composite soil sample must be taken from each area. Soil sampling is carried out using different sampling designs, which are indicated in the map or sketch of the targeted area. The selection of the sampling areas must follow these rules:

- The sampling area is no bigger than two hectares and is a field or part of it.
- The area should be uniform to avoid a mix of different kinds of soil.
- The area should have the same kind of vegetation or crop.

The most common samplings collection designs are the following:

- 1- Grid sampling: A grid with suitable spacing is placed on the map and measured. The sampling will be taken at the intersections of the grid or from inside of the grid cells. Grid sampling provides equally spaced observations and it reveals any systematic variation across the tract under study.
- 2- Random sampling: Sample locations are selected at random, with equal probabilities of selection and independently from each other. The sample produced from one sampling area consists of 10-20 sub-samples collected randomly throughout the sampling area using a zigzag pattern. The sub-samples should only be collected from representative sites, avoiding areas like anthills, bunds, boundaries, etc. The sampling process starts with the cleaning of the surface area then removing the top litter from the surface to approximately 1 cm deep. Dig a "V" shaped hole to a depth of 15 cm to collect a sample of the topsoil; for a sample of subsoil, the hole should be about 45 cm deep.
- 3- Random stratified sampling: The area is first divided into a number of subsections, called strata, and then random sampling design is applied to each of the strata separately. The random sampling method is not a systematic collection technique; meanwhile the stratified random sampling method provides a kind of mixture of the systematic and non-systematic soil sampling collection methods.
- 4- Transects: Soil samples are taken along straight lines across the targeted area. The spacing between sampling points might be equal, nested, or random.
- 5- Target sampling: Based on specific attributes (e.g. slope, aspect, plan or profile curvature, color, etc.) the technician identifies homogeneous and heterogeneous patterns of the targeted area, which

will allow the fixation of representative sampling points where the sampling will be taken. This technique minimizes the effort and cost and maximizes the information content.

### 3.2 Instructions for field experiments

#### 3.2.1 Research pilots

Research pilot in Grabow, Poland

Localisation of the experiment: Poland, Research Farm in Grabów, Warsaw Region, Zwolen District.

Type of experiment: annual, strict experiment, one – factor.

Factors of experiment:

- without irrigation (WI)
- irrigation without DSS system (intuitive irrigation) - (OutDSS)
- irrigation with DSS system (ENORASIS) – (WithDSS)

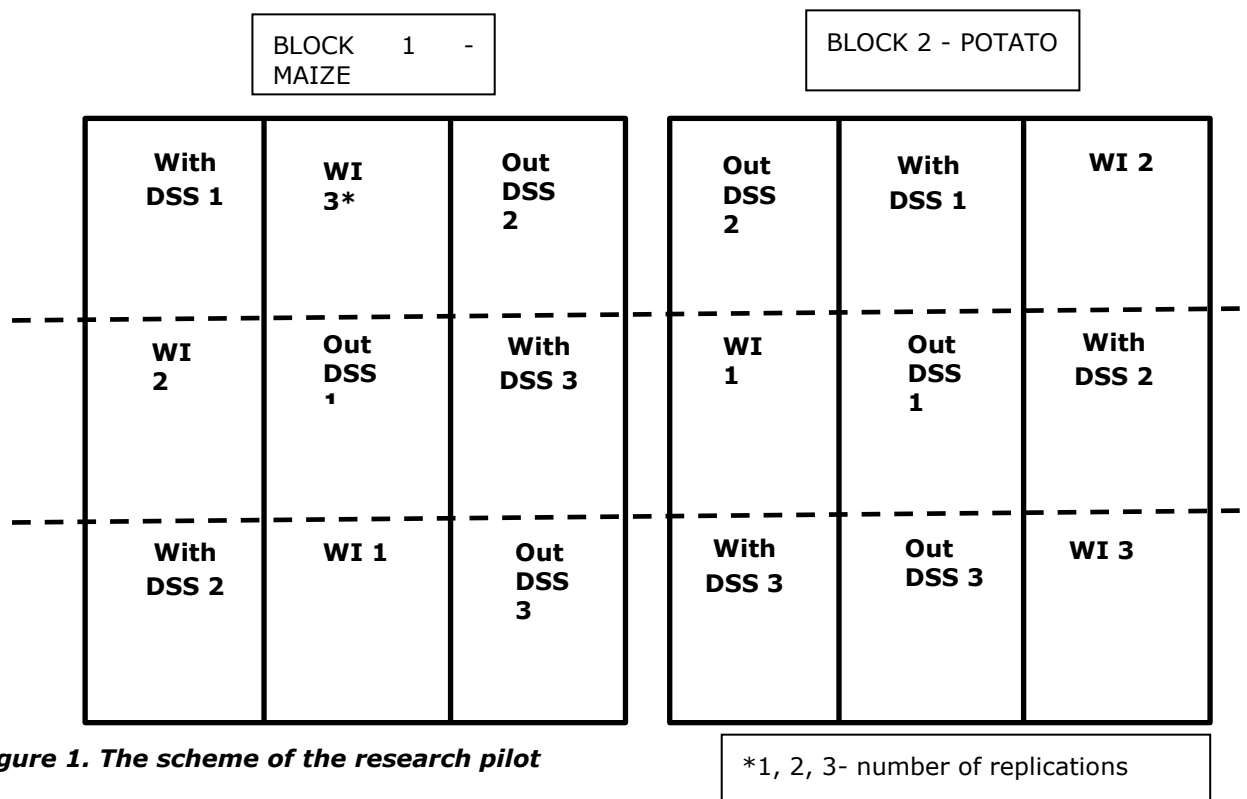
Vegetation seasons of experiment conducting: 2013-2014.

Research area: 1 hectare.

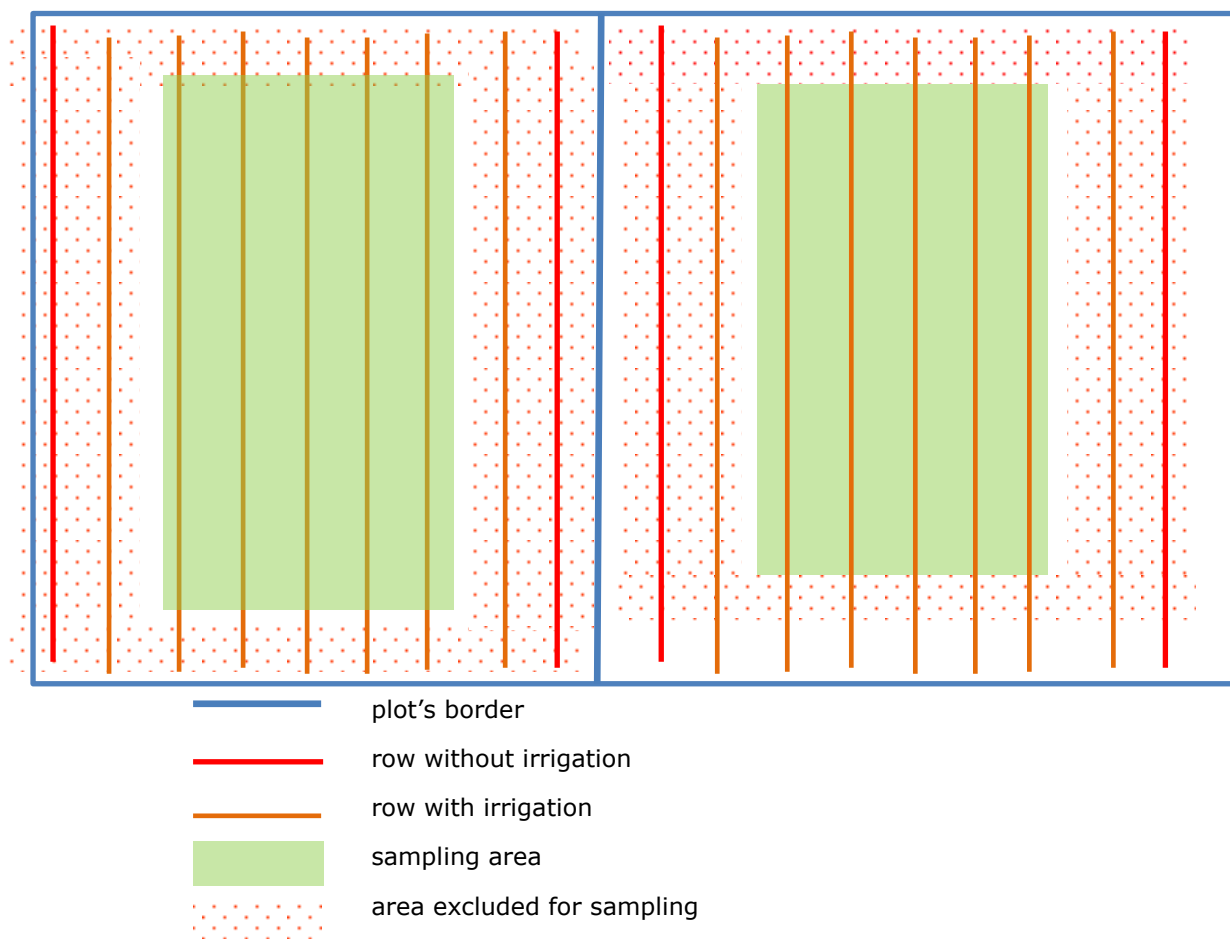
Investigated crops: potato, maize for corn.

Method of plot arrangement: split plot on randomized complete block

Irrigation system: drip irrigation.



**Figure 1. The scheme of the research pilot**



**Figure 2. The scheme of a single plot with border zones**

*Terms of conducting the experiment:*

- a. homogenous soil conditions within irrigation plot, texture: loamy sands
- b. previous crop: cereals;
- c. fertilization: potato: 160 kgN/ha, 70 P<sub>2</sub>O<sub>5</sub>, 160 K<sub>2</sub>O,  
maize: 120 kgN/ha, 60 P<sub>2</sub>O<sub>5</sub>, 80 K<sub>2</sub>O;
- d. tillage: typical for chosen crop species and variety;
- e. seeding/planting:
  - i. potato: end of April to beginning of May
  - ii. maize: first decade of May (13 crops per m<sup>2</sup>);
- f. maintenance: typical for the chosen crop (chemical protection, weed control).

- g. harvest:
- i. potato: second half of September,
  - ii. maize: November.

*Observations and measurements:*

- soil chemical analyses preceding seeding: pH [inKCl], P, K, Mg [mg/kg of soil] and Corg [%] content.
- Noting all the dates of treatment stages on pilot
- Seeding date or start of vegetation
- Daily ENORASIS irrigation plans
- Daily weather parameters: precipitation, solar radiation, wind speed, wind direction, air humidity, soil humidity, air pressure
- Daily amount of water actually used for irrigation
- End of irrigation period
- Harvest date/period
- Short description of agricultural practices: tillage, plant protection, harvesting technique ect.
- **Yield [t/ha] - for each crops and plots (15 measurements in total).**
- **Method for determining of yield from single plot:**

$$Y_p = \frac{y_1 + y_2 + y_3 + y_4 + y_5}{5} \times \frac{10000}{DiR \times DbR}$$

where:

Y<sub>p</sub> - yield from single plot;  
y<sub>1</sub>+y<sub>2</sub>+y<sub>3</sub>+y<sub>4</sub>+y<sub>5</sub> - total yield of 5 consecutive plants in a row;  
DiR - distance between crops in a row (m);  
DiB - distance between row (m).

*Quality parameters:*

- h. potato
- share of bulbs usable for sale [%]
  - share of tubers affected by diseases [%]
- i. maize
- humidity of corn after harvest

Research Pilot in Aydin, Turkey

*Localisation of experiment:* Turkey, Adnan Menderes University, Faculty of Agriculture, Research and Application Farm.

*Type of the experiment:* annual, field experiment, one – factor.

*Factors of experiment:*

- irrigation without DSS system (intuitive irrigation) - (OutDSS)
- irrigation with DSS system (ENORASIS) – (WithDSS)

*Years of experiment conducting:* 2013-2014.

*Experiment's area:* 1 hectare.

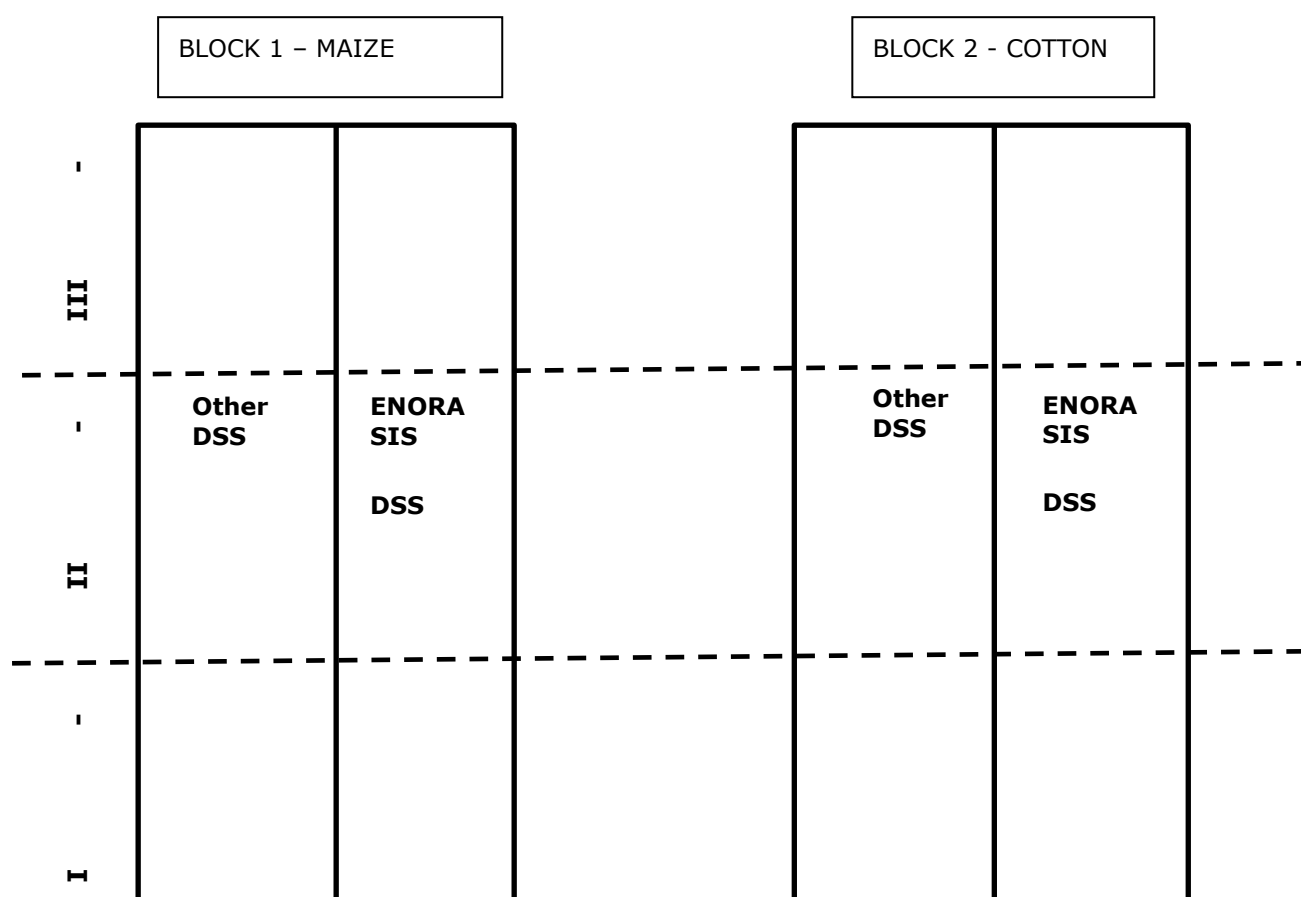
*Experimental crops:* maize, cotton.

*Method of plot arrangement:* complete block with plot replication.

*Irrigation system:*

- for maize and cotton - micro irrigation systems (drip, mini-sprinkler),

*Scheme of the experiment:*



**Figure 3. The scheme of the farm pilot in Turkey.**

*Terms of experiment conducting:*

- soil: : sand loam, eutric fluvisol
- previous crop: wheat;
- fertilization: maize: 120 kgN/ha, 60 P<sub>2</sub>O<sub>5</sub>, 60 K<sub>2</sub>O,  
cotton: 120 kgN/ha, 60 P<sub>2</sub>O<sub>5</sub>, 60 K<sub>2</sub>O;
- tillage: typical for chosen crop species and variety
- sowing/planting:
  - cotton: beginning of May,
  - maize: first decade of June;
- maintenance: typical for the crop species (chemical protection, weed control).
- harvest:
  - cotton: 15 September,

- maize: first decade of November

*Observations and measurements:*

- Soil chemical analyses preceding seeding: pH [inKCl], P, K, Mg [mg/kg of soil] and Corg [%] content.
- Noting the dates of all treatments on pilot.
- Seeding date or start of vegetation
- Daily ENORASIS irrigation plans
- Daily weather parameters: precipitation, solar radiation, wind speed, wind direction, air humidity, soil humidity, air pressure
- Daily amount of water actually used for irrigation
- End of irrigation period
- Harvest date/period
- Short description of agricultural practices: tillage, plant protection, harvesting technique ect.
- **Yield [t/ha] - for each crops and plots (12 measurements in total).**

- **Method for determining of yield from single plot:**

$$Y_p = \frac{y_1 + y_2 + y_3 + y_4 + y_5}{5} \times \frac{10000}{D_iR \times D_bR}$$

where:

Y<sub>p</sub> - yield from single plot;  
y<sub>1</sub>+y<sub>2</sub>+y<sub>3</sub>+y<sub>4</sub>+y<sub>5</sub> - total yield of 5 consecutive plants in a row;  
D<sub>i</sub>R - distance between crops in a row (m);  
D<sub>b</sub>R - distance between row (m).

*Quality parameters:*

- h. cotton
  - fiber length,
  - fiber resistance.
- i. maize
  - humidity of corn after harvest

### **3.2.2 Farm pilots**

Farm Pilot 1

*Localisation of the experiment:* Poland, Production Farm in Bobrowniki.

*Type of experiment:* annual, field experiment, one – factor.

*Factors of experiment:*

- irrigation with concurrent DSS system (commercial DSS) - (OtherDSS)
- irrigation with DSS system (ENORASIS) – (WithDSS)



*Vegetation seasons of experiment conducting: 2014.*

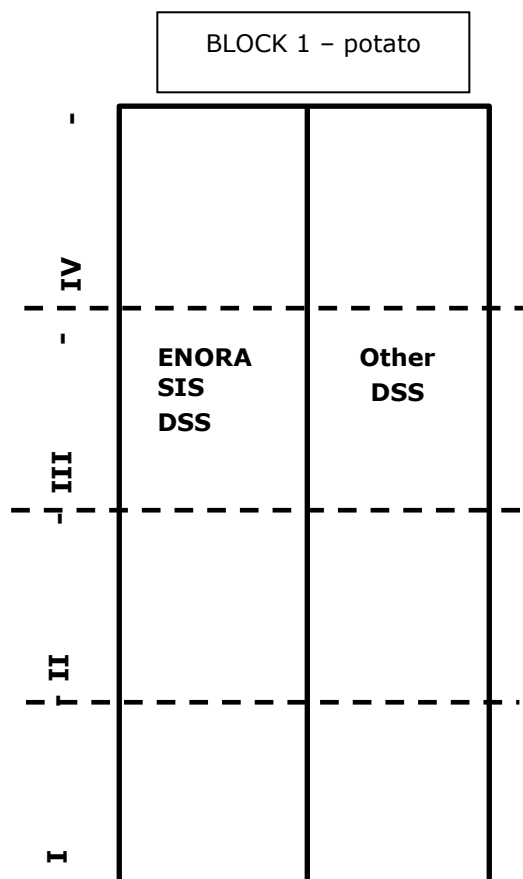
*Research area: 200m<sup>2</sup>.*

*Investigated crops: potato.*

*Method of plot arrangement: complete block with plot replication.*

*Irrigation system: sprinkler*

*Scheme of the experiment:*



**Figure 4. Scheme of the farm pilot at FF2, Poland**

*Terms of conducting the experiment:*

- j. soil: LS, SL
- k. previous crop: cereals;
- l. fertilization: 250 kgN/ha, 70 P<sub>2</sub>O<sub>5</sub>, 160 K<sub>2</sub>O,  
tillage: typical for chosen crop species and variety;
- m. seeding/planting:

- i. potato: end of April to beginning of May
- n. maintenance: typical for the chosen crop (chemical protection, weed control).
- o. harvest:
  - i. potato: second half of September,

*Observations and measurements:*

- soil chemical analyses preceding seeding: pH [inKCl], P, K, Mg [mg/kg of soil] and Corg [%] content.
- Seeding date or start of vegetation
- Daily ENORASIS irrigation plans
- Daily weather parameters: precipitation, solar radiation, wind speed, wind direction, air humidity, soil humidity, air pressure
- Daily amount of water actually used for irrigation
- End of irrigation period
- Harvest date/period
- Short description of agricultural practices: tillage, plant protection, harvesting technique ect.
- **Yield [t/ha] for each plots (8 measurements in total).**
- **Method for determining of yield from single plot:**

$$Y_p = \frac{y_1 + y_2 + y_3 + y_4 + y_5}{5} \times \frac{10000}{D_iR \times D_bR}$$

where:

- Y<sub>p</sub> - yield from single plot;
- y<sub>1</sub>+y<sub>2</sub>+y<sub>3</sub>+y<sub>4</sub>+y<sub>5</sub> - total yield of 5 consecutive plants in a row;
- D<sub>i</sub>R - distance between crops in a row (m);
- D<sub>b</sub>R - distance between row (m).

*Quality parameters: ?*

- share of bulbs usable for sale [%]
- share of tubers affected by diseases [%]

Farm Pilot 2

*Localisation of experiment:* Serbia, Delta Agrar

*Type of the experiment:* annual, field experiment, one – factor.

*Arrangement of the experiment's plots:*

irrigation with ab existing DSS system (commercial DSS) - (OtherDSS)

irrigation with DSS system (ENORASIS) – (WithDSS)

*Years of experiment conducting:* 2013-2014.

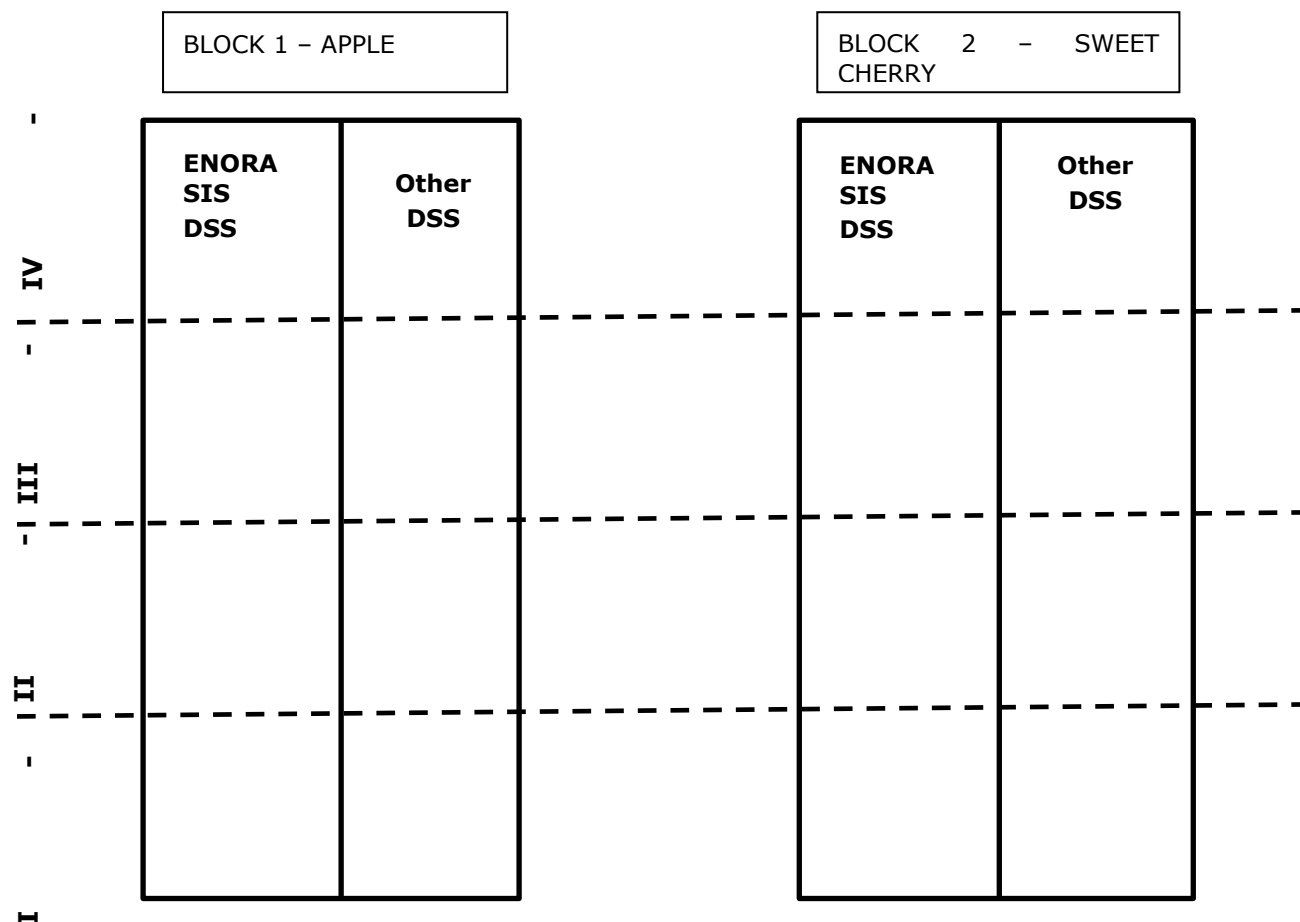
*Experiment's area:* 400m<sup>2</sup>.

*Experimental crops:* apple (variety: Braeburn), sweet cherry (Regina).

*Method of plot arrangement:* complete block with plot replication.

*Irrigation system:* micro irrigation systems (drip, mini-sprinkler).

*Scheme of the experiment:*



**Figure 5. The scheme of the farm pilot in Serbia.**

*Terms of experiment conducting:*

- a. Soil: homogenous soil conditions within irrigation plot, texture: chernozem
- b. fertilization:
  - apple : 300 kgNPK/ha,
  - sweet cherry: 300 kgNPK/ha;
- c. tillage: no tillage - permanent crops
- d. sowing/planting: none, existing orchard
- e. maintenance: typical for orchard plantations (chemical protection, weed control).
- f. harvest:
  - apple, machine harvesting: 20 August-5 October
  - sweet cherry : 10-20 July.

*Observations and measurements:*

- Noting the dates of all treatments on pilot.

- Date of the start of vegetation
- Daily ENORASIS irrigation plans
- Daily weather parameters: precipitation, solar radiation, wind speed, wind direction, air humidity, soil humidity, air pressure
- Daily amount of water actually used for irrigation
- End of irrigation period
- Harvest date/period
- **Yield [t/ha] - for each crops and plots (16 measurements in total).**
- **Method for determining of yield from single plot:**

$$Y_p = \frac{y_1 + y_2 + y_3}{3} \times \frac{10000}{D_{iR} \times D_{bR}}$$

where:

Y<sub>p</sub> - yield from single plot;  
 y<sub>1</sub>+y<sub>2</sub>+y<sub>3</sub> - total yield of 3 consecutive plants in a row;  
 D<sub>iR</sub> - distance between crops in a row (m);  
 D<sub>bR</sub> - distance between row (m).

- **Alternative method for determining of yield from single plot:**

$$Y_p = Y_1 + Y_2$$

where:

Y<sub>p</sub> - yield from plot;  
 Y<sub>1</sub>, Y<sub>2</sub> - total yield of whole row;

*Quality parameters:*

Apple and sweet cherry

- Quality class

### Farm Pilot 3

*Localisation of the experiment:* Cyprus, Fassouri Plantations.

*Type of experiment:* annual, field experiment, one – factor, participatory.

*Factors of experiment:*

irrigation without DSS system (intuitive irrigation) - (OutDSS)

irrigation with DSS system (ENORASIS), leaving the final decision on the irrigation to the farmer – (PartDSS)

*Years of experiment conducting:* 2013-2014.

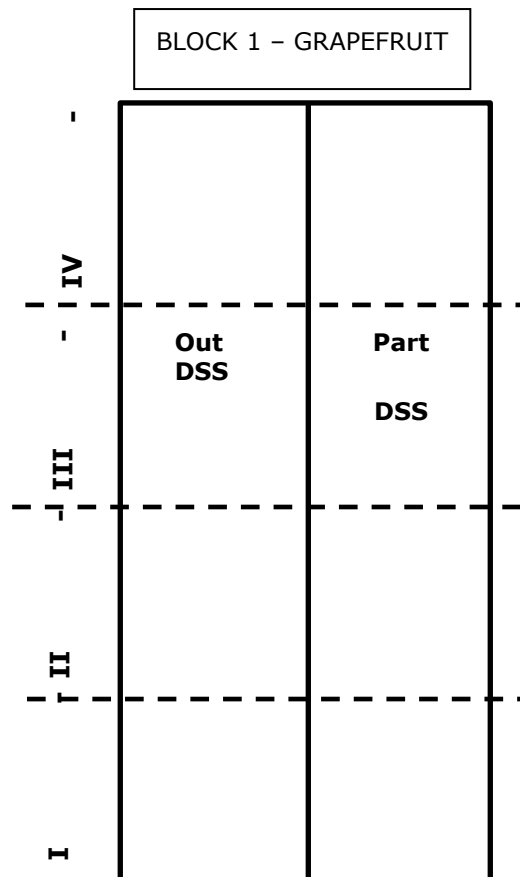
Experiment's area: 1000m<sup>2</sup>.

*Experimental crops:* Grapefruit, variety: Ruby Red.

*Method of plot arrangement:* complete block with plot replication.

*Irrigation system:* micro irrigation systems (drip, mini-sprinkler).

*Scheme of the experiment:*



*Experimental approach:*

The Cyprus pilot uses a participatory approach to evaluate the performance of ENORASIS at Fassouri Plantation Co, a large citrus production farm. The aim is to measure the ENORASIS performance indicators in a production farm setting, thus representing a real life case. The Fassouri Plantation staff believe that new technologies can help them save irrigation water and are cooperating with The Cyprus Institute researchers to test ENORASIS.

Involving users or clients in research and development is a key principle of successful innovation. User participation is a critical ingredient for relevant technology development, whether in agriculture or industry (Merril-Sands and Collion, 1994; Ashby and Sperling, 1995). Participatory research has its roots in international development. The participatory development 'paradigm' suggests two perspectives: the first of these consists of substantively involving local people in the selection, design, planning and implementation of projects that will affect them, thus ensuring that local perception, attitudes, values and knowledge are taken into account as fully and as soon as possible. The second is to make more continuous and comprehensive feedback an integral part of all development activities (Mikkelsen, 1995).

ENORASIS decision support will be provided for a 2-ha grapefruit field. The farm staff will use the ENORASIS advice to schedule their irrigations. The first ENORASIS option will be used, which should ensure that the crop will not experience water stress. However, the ultimate irrigation decisions lay with the Fassouri Plantation staff. These decisions could also be affected by typical operation problems such as water availability constraints. The Cyprus Institute researchers will closely follow all irrigation decisions, encourage the farm staff to follow the ENORASIS advice and note any deviations and reasons for these deviations. Standard irrigation practices will be followed at the adjacent 2-ha grapefruit field, which will serve as a control.

This approach ensures that we obtain the actual irrigation water use of a production farm and the savings that can be obtained by the use of ENORASIS in a real life setting. Finally, in case of deviations, potential ENORASIS savings can be analyzed by modeling all data collected during the season.

The farm will also be used for an ENORASIS demonstration workshop. Farmers and agricultural staff are often suspicious about the perfect results achieved and presented to them in research farms. Seeing and exchanging experiences with their farmer colleagues could make a much convincing case for ENORASIS.

*Terms of experiment conducting:*

- a. soil: : homogenous soil conditions within irrigation plot, texture: clay ;
- b. fertilization: 226 kgN/ha, 56 P<sub>2</sub>O<sub>5</sub>/ha, 150-188 K<sub>2</sub>O/ha
- c. tillage: no tillage permanent crops
- d. sown/planting: existing orchard
- e. maintenance: typical for the species (chemical protection, weed control).
- f. harvest: November (first round) and Feb-March (second round)

*Observations and measurements:*

- Note the dates of all treatments on pilot.
- Date of the start of vegetation
- Daily ENORASIS irrigation plans
- Detailed information on farmer's decision when decided not to irrigate according to ENORASIS suggestion.
- Daily weather parameters: precipitation, solar radiation, wind speed, wind direction, air humidity, soil humidity, air pressure
- Daily amount of water actually used for irrigation
- End of irrigation period
- Harvest date/period
- **Yield [t/ha] - for each plots (8 measurements in total).**
- **Method for determining of yield from single plot:**

$$Y_p = \frac{y_1 + y_2 + y_3}{3} \times \frac{10000}{D_{iR} \times D_{bR}}$$

where:

- Y<sub>p</sub> - yield from single plot;
- y<sub>1</sub>+y<sub>2</sub>+y<sub>3</sub> - total yield of 3 consecutive plants in a row;
- D<sub>iR</sub> - distance between crops in a row (m);
- D<sub>bR</sub> - distance between row (m).

*Quality parameters:*

- g. citrus:
  - quality class

### 3.3 Technical requirements for the pilots

- Each irrigated pilot plot should be equipped with minimum one soil moisture sensor, placed in representative part in the experimental field.

- Soil moisture measurement and meteorological measurement should be available (on-line) for ENORASIS platform during the pilot study
- Requirements for meteorological sensors used for ENORASIS pilots (obligatory for research pilot, optional for farm pilots):
  - Temperature and humidity sensor should be mounted on 2 meters above ground level (different level eg. 1.2 m is possible but please specify). Temperature sensor should be placed in radiation shield and should be located over an open area. The surface should be covered by short grass, or, where grass does not grow. Type of temperature sensor: Pt100 RTD or similar in accuracy, accuracy at +20°C  $\pm 0,2^{\circ}\text{C}$ .



**Photograph 1. Temperature and humidity sensor (Vaisala) mounted in a radiation shield (Aster – Polish manufacturer) and pyranometer sensor (Kipp&Zonen) mounted in one of IUNG’s agro weather stations (an example).**

- 
- Rain gauge – top of the sensor situated on 1 m high (please specify if different). Rain gauge should be placed in an open area, where there are no obstacles, such as building or trees, to block the rain. Preferable sensor: tipping-bucket mechanism. Sensitivity: 0.2 mm. Accuracy:  $\pm 4\%$ ,  $\pm 1\%$  rainfall count between 0.2 mm and 50.0 mm per hour;  $\pm 5\%$ ,  $\pm 1$  rainfall count between 50.0 mm and 100.0 mm per hour (eg. Davies Rain Collector II).



**Photograph 2. Rain gauge mounted at IUNG agro weather stations (an example)**

- Pyranometer (optionally), mounted in pen area with unrestricted view of the sky in all directions during all seasons, with the lowest solar elevation angle possible. Sensor height is not critical for pyranometers. Accuracy  $\pm 5\%$  (first class sensor) Spectral range: 285 to 2800 nm, Sensitivity: 5 to 20  $\mu\text{V}/\text{W}/\text{m}^2$ .

- Wind speed sensor (optionally) should be mounted in open terrain. Please specify the elevation of wind speed sensor above the ground level (eg. 2 m or 10 m). Accuracy: 0,3 m/s, starting threshold: 0,5 m/s.



**Photograph 3. Wind speed sensor mounted at one of IUNG's agro weather stations (an example)**

- Requirements for soil sensor measurement:
  - Sensor should be mounted on the root level depth – assumed 20cm. Type of the sensor: ... Accuracy:1% Resolution:5-100% .
- Photographs of installed meteorological sensors and soil moisture sensors should be taken for documentation.
- Meteorological sensors should be installed and the data availability for ENORASIS platform should be tested before the start of the vegetation season in 2013.
- Irrigation systems used in pilots should have functionality to measure the water volume consumption on each examined field (direct or indirect measurement).
- During the vegetation photo documentation describing the status of the crops should be done (number should be discussed).

### 3.4 Hardware control and maintenance

The control over the hardware installed on the pilot sites is charged to the pilot managers (chapter 5), supported by respective hardware providers (table 5):

- TEKNOSET, for the pilots in Turkey and Poland;
- FTS for the pilots in Serbia and Cyprus.

**Table 5. Hardware control and maintenance responsibilities among partners**

Country	Hardware	Provider	Action	Term/frequency
Poland	WSN network components	TEKNOSET	Check of the whole system connectivity	March 1 <sup>st</sup> 2014
	Soil Moisture sensors	TEKNOSET	Check of the installation and connectivity	After seeding, April/May 2014. On demand.



	AWS	IUNG	Check of the operation	March 1 <sup>st</sup> . Every week On demand, on alert.
Serbia	Soil Moisture sensor network	FTS	Check of the whole system connectivity	March 1 <sup>st</sup> 2014
	AWS	FTS	Check of the operation	March 1 <sup>st</sup> . Every week On demand, on alert.
Turkey	WSN network components	TEKNOSET	Check of the whole system connectivity	March 1 <sup>st</sup> 2014
	Soil Moisture sensors	TEKNOSET	Check of the installation and connectivity	After seeding, April/May 2014. On demand.
	AWS	TEKNOSET	Check of the operation	March 1 <sup>st</sup> . Every week On demand, on alert.
Cyprus	Soil Moisture sensor network	FTS	Check of the whole system connectivity	March 1 <sup>st</sup> 2014
	AWS	FTS	Check of the operation	March 1 <sup>st</sup> . On demand form Cyl
	All sensors	Cyl	Check of the operation	Every week On demand, on alert.

### 3.5 Key performance indicators

One of the main goals to perform pilot testing of the ENORASIS system is the evaluation of the economic efficiency and optimization of Enorasis irrigation decision support for irrigation. For this purpose, at the end of each from the two chosen vegetation seasons the person responsible for conducting a particular pilot has to collect and provide to following data:

- Yield of crops in experiment [t/ha]
- Average price for yield [Euro/t]
- Water consumption [m<sup>3</sup>/ha]
- Price for m<sup>3</sup> of water [Euro]
- Energy consumption in Kwh
- Cost of Kwh of energy

Along with data on daily water use and meteorological data collected throughout the vegetation season.

The collected data will allow to judge system's performance basing upon two groups of indicators:

#### Agri-Environmental irrigation indicators

En.1. Water consumption per unit yield; [m<sup>3</sup>/Mg]

En. 2. Water consumption per unit yield difference; [m<sup>3</sup>/Mg]

#### Economical irrigation indicators

Ec. 1. Water irrigation cost per unit yield; [Euro/Mg]

Ec. 2. Energy cost of irrigation per unit yield; [Euro/Mg]

Ec. 3. Economic efficiency of irrigation; [Euro/Mg]

Ec. 4. Yield quality indicator [% HQ yield]

## 4. REPORTING ON PILOT PROGRESS

The progress of the pilot will be monitored and reported by the responsible person. Three major reports in each vegetation period are to be submitted to the leader of work package 6:

- Pilot starting report, covering the circumstances in which the pilot was initiated;
- Mid-season report, covering the information on the plant growth, water usage and energy consumption;
- End-of-Season report, covering the information on crop yield, total power and water consumption throughout the vegetation period.

Additionally following data should be gathered and provided in respective time intervals (tab 5).

**Table 6. Pilot monitoring data.**

Data/information	Frequency	Description
Daily water use	daily	Table
Phenological phase	>7 days	Phase and/or picture

## 5. RESPONSIBLE PERSONS

**Table 7. Responsible persons**

Country	Name	Surname	Institution	E-mail	Phone number
Poland	Mariusz	Matyka	IUNG-PIB	<a href="mailto:mmatyka@iung.pulawy.pl">mmatyka@iung.pulawy.pl</a>	+48 81 8863421 ext. 359
	Jerzy	Kozyra	IUNG-PIB	<a href="mailto:kozyr@iung.pulawy.pl">kozyr@iung.pulawy.pl</a>	+48 81 8863421 ext. 236
Serbia	Ratko	Bajčetić	PWMC Vode Vojvodine - VoVo	<a href="mailto:rbajcetic@vodevojvodine.com">rbajcetic@vodevojvodine.com</a>	+381 21 4881523
	Jelena	Vojvodić	PWMC Vode Vojvodine - VoVo	<a href="mailto:jvojvodic@vodevojvodine.com">jvojvodic@vodevojvodine.com</a>	+381 21 4881519
	Vladan	Minić	FTS	<a href="mailto:vladan.minic.ns@gmail.com">vladan.minic.ns@gmail.com</a>	+381 21 4852523
Turkey	Bekir Sitki	Karataş	Adnan Menderes University, Faculty of Agriculture	<a href="mailto:bkaratas@adu.edu.tr">bkaratas@adu.edu.tr</a>	+90 256 7727022/1710-1712
	Ömer Faruk	Durdu	Adnan Menderes University, Faculty of Agriculture	<a href="mailto:odurdu@adu.edu.tr">odurdu@adu.edu.tr</a>	+90 256 7727022
	Talih	Gürbüz	Adnan Menderes University, Faculty of Agriculture	<a href="mailto:tgurbuz@adu.edu.tr">tgurbuz@adu.edu.tr</a>	+90 256 7727022/1709
Cyprus	Adriana	Bruggeman	Cyl	<a href="mailto:a.bruggeman@cyi.ac.cy">a.bruggeman@cyi.ac.cy</a>	+357-22-208620
	Hakan	Djuma	Cyl	<a href="mailto:h.djuma@cyi.ac.cy">h.djuma@cyi.ac.cy</a>	+357-22-208686

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## ANNEXES

### Annex I. Start of the season report

#### **General information**

**Year:**

**Localization of the experiment:**

**Cultivated crops:**

**Responsible person:**

#### **Description of weather conditions before the start of pilots**

#### **Results of chemical analyzes of soil samples collected before the start of pilots**

Date of sampling	Depth (cm)	Irrigation plot ID	pH in		Contents in 100 g of soil (mg)			Soil organic carbon (%)
			H <sub>2</sub> O	KCl	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Mg	

#### **Plan of experiments**

Draw a detailed plan of experiments showing the actual distribution of plots. Please put in figure the irrigation system diagram. Please specify terrain aspect of irrigated plots, indicating numbers of plots, the nearest roads, trees, buildings, soil sampling points.

<b>Size of plots (m)</b>	<b>length</b>	<b>width</b>
overall	.....	.....
harvest sampling*	.....	.....

*\*Sampling method in Pilot Implementation Guidelines*



**Distance between plants (m)**

**in row**

**between rows**

.....

.....

***Photo documentation***

Please take a picture before the start of the experiment and a day after after the start.

***Problems with the implementation of pilot and derogation from the guidelines***

Date of incident	Irrigation plot ID	Description of incident	Potential consequences for the realization of pilot

## Annex II. Mid-season report

### General information

**Year:**

**Localization of the experiment:**

**Cultivated crops:**

**Responsible person:**

### Fertilization and crop protection

Crop 1:					
Irrigation plot ID	Fertilizer or pesticide	% pure component (fertilizer or active substance)	NPK dose (t/ha)	Organic fertilization (dose t/ha plus content of NPK%)	Date of application

Crop 2:					
Irrigation plot ID	Fertilizer or pesticide	% pure component (fertilizer or active substance)	NPK dose (t/ha)	Organic fertilization (dose t/ha plus content of NPK%)	Date of application

### Agrotechnical treatments

Crop 1:			
Irrigation plot ID	Date of treatment	Type of used machinery and tractor (power in kW)	Type of treatment and implementation method



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<b>Crop 2:</b>			
Irrigation plot ID	Date of treatment	Type of used machinery and tractor (power in kW)	Type of treatment and implementation method

***Phenological development stages (in BBCH – scale)***

<b>Crop 1 :</b>		
Code	Descriptive name of the phase	Date of observation

<b>Crop 2 :</b>		
Code	Descriptive name of the phase	Date of observation






### ***Problems and derogations from the pilot implementation guidelines***

No	Date of incident	Problem identification	Problem description	Potential consequences for the realization of the pilot

### ***Photo documentation***

Please take digital pictures in time interval not longer than 7 days.  
 RAW format preferred. Otherwise TIFF and PNG.

## Annex III. End of the season report

### **General information**

**Year:**

**Localization of the experiment:**

**Cultivated crops:**

**Responsible person:**

### **Fertilization and crop protection**

<b>Crop 1:</b>					
Irrigation plot ID	Fertilizer or pesticide	% pure component in fertilizer or active substance in pesticide	NPK dose (t/ha)	Organic fertilization (dose t/ha and content of NPK%)	Date of application

<b>Crop 2:</b>					
Irrigation plot ID	Fertilizer or pesticide	% pure component in fertilizer or active substance in pesticide	NPK dose (t/ha)	Organic fertilization (dose t/ha and content of NPK%)	Date of application

### **Agrotechnical treatments**

<b>Crop 1:</b>			
Irrigation plot ID	Date of treatment	Type of used machinery and tractor (power in kW)	Type of treatment and implementation method

<b>Crop 2:</b>			
Irrigation plot ID	Date of treatment	Type of used machinery and tractor (power in kW)	Type of treatment and implementation method

### **Phenological development stages of plant (in BBCH – scale)**

<b>Crop 1 :</b>		
Code	Descriptive name of the phase	Date of observation


<b>Crop 2 :</b>		
Code	Descriptive name of the phase	Date of observation

### ***Daily water consumption***

<b>Crop 1 :</b>		
Date	Standard irrigation (mm/m <sup>2</sup> /day)	ENORASIS (DSS) system irrigation (mm/m <sup>2</sup> /day)

<b>Crop 2 :</b>		
Date	Standard irrigation (mm/m <sup>2</sup> )	ENORASIS (DSS) system irrigation (mm/m <sup>2</sup> )

Water price (Euro/m<sup>3</sup>):

**Energy consumption**

<b>Crop 1 :</b>	
Standard irrigation without DSS (Kwh)	ENORASIS (DSS) system irrigation (Kwh)
<b>Crop 2 :</b>	

Energy price (Euro/Kwh):

**Results of experiments**

Yield

<b>Crop 1:</b>				
Irrigation system	ID of plot (replication*)	Yield (t/ha)	Humidity of corn***	Price of yield
ENORASIS DSS				

	<b>sum</b>			
Irrigated without DSS				
	<b>sum</b>			
No irrigation**				
	<b>sum</b>			
	<b>sum</b>			
	<b>sum</b>			
	<b>sum</b>			

\* replication ID with accordance to guidelines;

\*\* only for pilot in Poland;

\*\*\* only for maize.

<b>Crop 2:</b>				
Irrigation system	ID of plot (replication*)	Yield (t/ha)	Humidity of corn***	Price of yield
ENORASIS DSS				
	<b>sum</b>			
Irrigated without DSS				
	<b>sum</b>			
No irrigation**				
	<b>sum</b>			

	<b>sum</b>			
	<b>mean</b>			

- \* replication ID with accordance to guidelines;
- \*\* only for pilot in Poland;
- \*\*\* only for maize.

Quality parameters

<b>Crop 1:</b>			
Irrigation system	Name of quality parameter*	Value or description** (xx)**	Humidity of corn***
ENORASIS DSS			
	<b>sum</b>		
	<b>mean</b>		
Irrigated without DSS			
	<b>sum</b>		
	<b>mean</b>		
No irrigation****			
	<b>sum</b>		
	<b>mean</b>		

- \* quality parameters for each pilot and crop are specified in guidelines;
- \*\* description for quality of mesocarp and organoleptic properties of fruit in Serbian and Cyprus pilots;
- \*\*\* please specify the unit of measure;
- \*\*\*\* only for pilots in Poland.

<b>Crop 2:</b>			
Irrigation system	Name of the quality parameter*	Value or description** (xx)**	Humidity of corn***
ENORASIS DSS			
	<b>sum</b>		
	<b>mean</b>		
Irrigated without DSS			
	<b>sum</b>		
	<b>mean</b>		
No irrigation****			
	<b>sum</b>		
	<b>mean</b>		

- \* quality parameters for each pilot and crops are specified in guidelines;
- \*\* description for quality of mesocarp and organoleptic properties of fruit in Serbian and Cyprus pilots;
- \*\*\* please specify the unit of measure;
- \*\*\*\* only for pilots in Poland.



---

### ***Problems and derogations from the guidelines***

No	Date of incident	Problem identification	Problem description	Potential consequences for the realization of pilot

### ***Photo documentation***

Please take digital pictures at intervals of not more than 7 days.  
RAW pictures preferred, TIFF and PNG acceptable.  
Only photos taken at the time from last mid-term report.