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FATIMA

FArming Tools for external nutrient Inputs and water MAnagement

D5.1: Baseline description & demonstration framework

WP5– Pilots / demonstration cases and strategic integration

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Executive summary

This report gives an overview of the features of the seven pilot areas. All of them follow the same goal of improving the input of resources to reach a more sustainable form of agriculture, but to represent this on a European scale, different areas with different climate, topography and crops were selected.

Deliverable D5.1 gives an introduction into the geographic location, farm structures, main crops, climate and groundwater conditions of the seven pilot areas. It points out the main challenges and the most important policies related to agriculture. The report summarises current practices related to irrigation, water supply and wastewater treatment. FATIMA aims at responding to the real needs in the single pilot areas; therefore the user requirements are highlighted in this document.

The campaigns are the mechanism to provide the required datasets (from field measurements, sensor on machinery, EO data, ground sensor data, stakeholder data) that are needed to generate FATIMA portfolio of products for stakeholder test groups. This report gives an introduction on the goals of the campaigns in the different pilot areas, gives preliminary results and shows what is planned in the season 2016.

The summary of the different pilot areas showed that even though all of them feature different physical conditions and focus on different crops, all face similar problems and aim at a decreased input of water and/or nitrogen fertilizer. The package of experiments connected to the implementation of earth observation technologies and the development of the WebGIS will give an integrated response to the most urgent problems in the pilot areas which – due to their different attributes- represent European agriculture.

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EO	Earth Observation
PE	Population Equivalent
RBMP	River Basin Management Plan
VRT	Variable Rate Technology
WFD	Water Framework Directive
WWTP	Waste Water Treatment Plant

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1 Objective and scope of the work

1.1 Scope

The objective of this report is to provide an overview of the seven different pilot areas and of the demonstration activities within the FATIMA project. The different pilots and experiments all aim at improving the agricultural management to reach more sustainable ways of using natural resources as water, energy and nutrients, but still they feature different climate, topography and crops – not forgetting different cultures, languages and attitudes.

We aim at comparing the pilot areas, find similarities, but also highlighting differences between the different locations. In this way, possible synergies between "similar" pilot areas shall be found to increase the cooperation between the partners and the exchange of know-how. On the other side, also the differences can improve the own performance. The report highlights the strengths and working focus of the single partners, which are complementary within the pilot area, but also within the whole project.

The document also outlines the campaign plans for the field trials, short "dry run" and demonstration campaigns and shows how the planned FATIMA products tackle the challenges in the pilot areas.

1.2 Contents

At the beginning of May 2015, and as a first Work Package 5 (WP5) activity in the pilot areas, Regional Managers were invited to collect the baseline information for the pilot area. The inputs from each of the pilot areas were obtained during May and July 2015 and complemented during the 1st Plenary Meeting, which took place in Albacete in October 2015 by interviewing local teams.

Further input came from:

- Deliverable D1.1.2 (Stakeholder and institutional mapping repots), which gives a summary of the 1st regional meetings and highlights the main challenges discussed during the meetings;
- Deliverable D3.3.1 (Framework for soil-crops assessment and nutrient management in pilot areas), which explains the field trials in Spain, Italy and Austria in the context of soil conservation;
- The pilot roadmaps, which serve as guideline for the campaigns

Based on this information, the document summarizes the main features of pilot areas. It collects basic geographic information on location and topography of the pilot areas. As water scarcity is an important topic, the climate of the pilot areas is explained with climate charts.

The main agricultural structures related to the average farm and plot size, irrigation infrastructure, average fertilization and irrigation values and the most important crops are outlined.

The main challenges and the legal framework of each pilot are highlighted. During the 1st plenary meeting from 7-9th of October in Albacete (Spain), representatives of users from all pilot areas exposed their most urgent issues for crop management. A summary of the single statements is given in the section on user requirements. Tools and approaches to respond to the users' requirements are developed in the context of pilot campaigns.

2 The concept of pilot campaigns

Participatory evaluation of the FATIMA prototype jointly with users and other stakeholders is the core element of the project. The corresponding activities are assembled in Work-Packages 1 and 5 (WP1 and WP5). The main objective is here to evaluate the use and performance of the toolsets for irrigation water and nutrient inputs management in our pilot case studies.

The campaigns are a basic piece in this evaluation. First, they are the mechanism to provide the required datasets (from field measurements, sensor on machinery, EO data, ground sensor data, stakeholder data) that are needed to generate FATIMA portfolio of products for stakeholder test groups (WP5). Second, they provide the frame of reference for the stakeholder evaluation process and policy recommendations (WP4) and to conduct experiments for new products and cropping system development (WP2 and WP3).

The seven pilot areas have been selected according to major crops in intensive production and/or with nutrient/water consumption (based on Eurostat latest statistics), as well as to the most promising precursor applications and implementation conditions (e.g., testbeds for key component developments). They are located in Spain, Italy, Austria, Turkey, Greece, France and Czech Republic.

The campaigns will be adapted to the specific character of each pilot area and the stakeholder component will be tuned to the specific agricultural challenge in the area. All elements of the FATIMA prototype will be factually (physically, electronically, people) brought together: setup of local Modelling and Decision Support System (MDSS) configuration (admin & user groups; model configuration, upload of basic GIS layers); setup/installation of ground-based sensor networks and two-way connection with central MDSS; setup of EO images procurement and production line (basic processing and products generation); training of Core Users in MDSS & sensor network use; joint definition of validation criteria & protocol; short “dry run” (2-4 weeks) of all deployed elements together for testing purposes. The demonstration campaign will activate all FATIMA elements in a given pilot area.

The campaign-related tasks are split into technical issues (technical data collection and analysis, product development, validation and generation and upload of GIS info layers and data in SPIDER; part of WP2, WP3 and WP5) and non-technical issues (framework, training, stakeholder process and evaluation, marketing, policy; part of WP1, WP4 and WP6). The integration and summary is conducted in WP5.

2.1 Design and planning of the preparatory campaigns

Short “dry run” (2-4 weeks) campaigns (on-going in 2015 and 2016) will be performed to check the operation of different basic elements to be implemented in each pilot area, to test some of the elements of the chain, and to familiarize users with it. In all cases the basic elements of “common scenario services” must be checked.

The first test of the production chain and of the use of its products by users is one of the main goals of this activity. Results will serve to refine the basic products, adapt the user´s basic capabilities to receive it and the capabilities to use it into the current procedure.

The basic objective and purpose of “dry run” campaigns is to get everything and everybody ready for the demonstration campaign (2016-2017). The following table provides an overview.

Table 1 Short dry-run campaign plan

Preparation focus	Preparatory activities

Team	Consolidate roles of each partner / each person; Provide training as needed;
Data and systems	webGIA implementation; Upload all data marked "A" (=available) (in lists of Appendix A); Start collecting data marked "TBC" (=to be collected); Test technical issues, such as calibration/validation of (new) products in (new) areas;
Stakeholders	Train the Core User(s); Set up the local community;
Operations	Test whole chain from satellite to stakeholder (for a small set of 2-3 images): • Image collection; • Basic EO processing and product generation; • Upload to webGIS.

The expected outcome of the short dry run campaigns is a "System and people fit for operational pilot campaigns."

2.2 Design and planning of the demonstration campaigns

Operational pilot campaigns will be performed in each pilot area starting from 2016 for at least one growing season. They include the following three components:

Component 1 - EO products: Download of images; Image processing & quality control;

Component 2 - "in-field sensor data": Download of data (e.g. agromet, soil water content); Field work & surveys;

Component 3 - Processing/analysis of campaign data (merge "local data streams" & "operational data streams"), product generation & Quality Control; upload to webGIS; Cross-pilot synthesis.

The objective and purpose of these campaigns is twofold:

(1) to provide the required datasets (field measurements, EO data, additional data, stakeholder data and perceptions) that are needed to generate FATIMA portfolio products for stakeholder test groups (WP1); and

(2) to provide the frame of reference, training, and guidance for the stakeholder evaluation process (WP1 and WP5).

For the generation of the fertilization & irrigation recommendations, the campaigns involve the following elements in an iterative sequence:

(i) image acquisition bi-weekly or monthly (depending on timing within crop growing cycle), according to image requirements listed in Table 2;

(ii) field data collection (weekly complementary field measurements of crop phenology, height, fractional cover, leaf chlorophyll content and area index; continuous agrometeorological station data and soil water content measurements; seasonal soil nutrient mapping);

(iii) generation of multi- level EO-assisted products in (near-)operational mode (at farm, irrigation scheme) according to operational processing chain defined in WP2, including quality control;

(iv) upload of all products to webGIS database (both space & field segment);

(v) provision of information products to Core Users and stakeholder control group (set up in WP1) at all levels via web-based on-line webGIS modules or email or in paper (depending on infrastructure available to user). Users receive monthly products and accumulated end-of-season products;

(vi) continuous participatory evaluation with Core Users and other stakeholders.

Detailed guidelines and methodological descriptions for all elements are given in the documents:

- Dense high-resolution EO time series, gap filled (D2.2.1)
- EO-based crop water requirements forecast (D2.2.2)
- Biophysical-biochemical parameters from new EO (D2.2.3)
- EO maps of nutrient requirements and of yield (D2.2.4)
- Mapping N from EO at a range of spatial scales (D3.2.1)
- Central webGIS prototype & users guide (D2.1.2)

Table 2: EO data requirements for pilot campaign evaluation of FATIMA.

	Irrigation	Fertilizer
Which images?	12-15 images from high-resolution (HR) satellites (Landsat8 and Sentinel-2) in Virtual Constellation	same; plus time series of very high resolution data (Rapid-Eye, WorldView-2)
Revisit frequency and time period to be covered	Monthly or bi-weekly (depending on crop growing stage) during 6 months (average growing season duration). Near-real-time (products generated within 24h from overpass)	Acquired at key phenological stages
Area to be covered	Minimum areal coverage will be the size of the pilot area	same;
Spatial resolution	10-20 m	2-10 m

2.3 Participatory evaluation and validation with users

The products will be provided for participatory evaluation and validation with users during one growing season. Normally, users will receive updates every 8-14 days. This implies procurement of EO images and product generation in a temporal sequence of 1-2 weeks in near-real-time mode (1-2 days after satellite overpass). EO-derived products are then uploaded/integrated in MDSS, together with model- and ground-sensor-derived products, and available there for consultation, visualization, and analysis by the users. Each time the Core Users receive updates from FATIMA solutions, they record their routine decision-making and operations and the difference introduced by the FATIMA solutions. At the end of the demonstration campaign, this constitutes their evaluation log (WP5). We distinguish 3 steps of the validation process:

1-Verification (technical checks of conformity with specification);

2-Participatory assessment with users and evaluation (based on evaluation protocol & criteria for “fit for purpose”); this step gives indications on efficiency & “usefulness” of FATIMA solutions; the evaluation criteria include accuracy (“at least as good as field data”), information content (spatial resolution and coverage of large areas), reliability, economic viability, social benefits, and cultural acceptance.

3-Validation (confirmation from users that FATIMA solutions are what they want, based on validation protocol & criteria); this step gives conclusions on effectiveness and cost-benefit & further impact, it demonstrates if/that FATIMA solutions “make a difference” for the users and their environment

The following tables provide a summary of the seven pilot studies. They highlight available data and give an overview of the baseline information.

Table 3: EO and sensor data requirements

EO/data requirements	Description	AT	CZ	ES	FR	GR	IT	TR
Satellite(s) owned or free		Mostly free (Landsat/SPOT-5/Sentinel-2) with some very high resolution commercial data	Mostly free (Landsat8/SPOT-5/Sentinel-2A)	Mostly free (Landsat/SPOT-5/Sentinel-2) with some very high resolution commercial data	Mostly free (Landsat/SPOT-5/Sentinel-2) with some very high resolution commercial data	Mostly very high resolution WorldView-2 with some free medium resolution data(Landsat/Sentinel-2)	Mostly free (Landsat/SPOT-5/Sentinel-2) with some very high resolution commercial data	Landsat 8 (supported potentially by some higher res. data)
Year of images for short dry run campaign	Selected year	2015/2016	2016	2015/2016	2015-2016-2017	2015/2016	2015/2016	2015/2016
Number of images	2014	10 + (Deimos and Landsat)		≈ 30 (Landsat, overlapped area by adjacent path)		-	n. 7 Landsat 8	-
	2015	20 + (Deimos/Landsat/SPOT-5/Sentinel-2)	Together 44 scenes from Landsat 8. Due to cloudiness only 12 images usable. For capturing field variability, 2 scenes used.	≈ 50 (Deimos/Landsat/SPOT-5/Sentinel-2)	26 (16 Landsat+10 SPOT5)	4 WV-2 and5Landsat 8 images (plus 1 WV-2 during December)	n. 10 landsat 8	10 (Landsat 8)
	2016	Planning for Sentinel-2	Planning for Sentinel-2	Planning for Landsat8+Sentinel2a		Planningfor WV-2 and Landsat-8 and Sentinel-2data	Planning for Sentinel-2 and Landsat8	Landsat 8 + Sentinel-2 (when available)

Vector layer provider	Who?	Individual farmers involded in test & development activities	LPIS (Land Parcel Identification System (a vector layer of field blocks) + info from farmers	Yes from cadaster + own elaboration	INRA, Farmer	Remote sensing and field work	Consorzio Di Bonifica Della Maremma Etrusca	Irrigation Association + Local Municipality
Agromet station data provider	Who?	Own stations + Weather forecast data	Own stations + Weather forecast data	SIAR +AEMET	INRA, farmer, Meteo-France	Meteo Larisa (private station, linked to the greek network Meteo.gr)	Regional Agency (ARPA) Stations + Weather forecast data (ARPA SIM – Commercial Agreement to be implemented)	UTAEM + State Meteorological Services
Soil map data provider	Who?	National provider (Field capacity and wilting point)	Data from Agrochemical Soil Testing + ESEU (Evaluated Soil Ecological unit) + own soil survey (soil chemistry & physics	Own +National provider	National Provider, INRA (hydraulic characterizatio n, soil resistivity, texture, nitrogen balance	NAGREF	Lazio Soil maps 1:250.000 (CREA)	UTAEM

Land cover /use data provider	Who?	Own production based on remote sensing and in-situ data	Own production based on remote sensing and in-situ data	Own production based on remote sensing and ancillary data (cadaster)	Corine Land cover INRA for the Crau Area	Own production based on remote sensing and in-situ data	CREA	Corine Land Cover 2006 for Turkey (+ local data if available by UTAEM)
Image processing & upload	Who?	BOKU	METCENAS + external	UCLM	UCLM, INRA	AUA and Sigma	ARIESPACE	EA-TEK

Table 4: Information layers and other data to be uploaded in the MDSS (A-available, TBC- to be confirmed)

Layer/data	Description	AT	CZ	ES	FR	GR	IT	TR
Satellite images	Images without further processing	A	TBC	A	SPOT (2015 A, 2016, 2017 TBC) – Landsat (A. 2015-2017), Sentinelle (TBC)	A	A	A
Satellite image basic products	RGB, NDVI, Chlorophyll index	A	A	A	A + LAI	A	A	A
Boundary of the area to be monitored using satellite time series	Shapefile in decimal degrees of UTM coordinates (DATUM WGS 84)	A	A	A	A	A	A	A
Vector layer	Cadastral map or shape file of field plots	A	A	A	A (studied field)	A	TBC	A
Agromet station data	Coordinates of Station(s); and daily temperature & rainfall data	A	A	A	A	A	A	A
Agromet station data	Daily or weekly ET0 data	A	A	A	A	TBC	TBC	A
Soil map	Attributes: depth, field capacity and wilting point	A	A	A	TBC	A	A	TBC
Land cover/use inventory	Focus on irrigated areas	A	A	A	A (Corinne,OcSol 2007, 2014 TBC)	TBC	TBC	TBC

Table 5: Summary of the basic information

	AT	CZ	ES	FR	GR	IT	TR
Size (ha)	90.000	55	1.000.000	32.000	1.050.000	27.000	20.600
% of agriculturally used land	75	89	40	50	36	67	80
Located in NVZ (yes/no)	yes	yes	Partly		partly	partly	
Main challenge	High nitrate levels in groundwater	High nitrate levels in drainage water	Aquifer depletion High nitrate levels in groundwater	Low efficiency in nitrate and water use	Limited water availability High water and fertilizer use	Groundwater pollution High production costs	High pressure on water resources, water and soil pollution
Three main crops	Wheat, vegetables, maize	Red clover, wheat, barley	Wheat, wine, maize	Wheat, sunflower, tomato	Wheat, cotton	Wheat, tomatoes, Watermelon	Cotton, wine, maize
Annual precipitation [mm]	550	660	350	700	700	670	540
% of irrigated plots	30	0	25		24	10	67

Table 6: Summary of the campaign focus

	AT	CZ	ES	FR	GR	IT	TR
WebGIS tools and data for demonstration campaign*	Irrisat & EO (Sentinel-2 & Landsat-8)	SPIDER, ground sensors & EO (Sentinel-2)	SPIDER & EO (Sentinel-2 & Landsat-8)	SPIDER, very high resolution data from drones	SPIDER & ground sensors + Very high resolution (WV-2)	Irrisat & EO (Sentinel-2 & Landsat-8)	SPIDER & EO & basic sensors
Focus of calibration & validation campaign**	nutrients & EO, connection with WP2/WP3	VRT, sensors, lysimeters (WP3.1)	nutrients & EO, yield, WP3.2, Forecast	Assimilation of EO data in Crop Growth models	VRT machine, sensors (WP3.1)	nutrients & EO, WP3.3 (experiments on different types of fertilizers) Forecast	None at the moment
Users	A group of farmers in the region; An institutional user (AGES)	The local farm cooperative	A group of farmers in the region; Experimental farm;	One test-farmer (Jerome Grangier)	None at the moment	The farm cooperative	1-2 end-users; water user association will be involved when product is ready
2nd regional meeting	January 2016	November 2015	November 2015	November 2015	Internal meeting of the regional team in Nov/Jan 15/16	Jan/Feb 2016	January 2016

*Demonstration campaign: the framework in which FATIMA tools are deployed for demonstration and evaluation with users

**Calibration & validation campaign: the framework in which field experimental activities are carried out to develop, improve and validate methodologies to produce and deliver FATIMA products and tools.

3 Marchfeld (Austria AT)

The Marchfeld region is located in Eastern Austria and it is the most intensively used agricultural area in Austria. Even though winter crops such as wheat covers the largest area, sugarbeet and vegetables like onions, potatoes, peas, carrots and spinach require large amounts of water, which cannot be satisfied by the annual precipitation of around 500 mm. Groundwater is the main water source for irrigation and, as fertilization activities release nitrogen, the aquifer is negatively affected in terms of quality and quantity. Nitrate pollution of groundwater is therefore the main challenge in the area.

FATIMA will tackle these problems by providing improved fertilizer and irrigation recommendations to both institutions and individual farmers.

3.1 Overview

3.1.1 Geography

Marchfeld in Austria is the main production area of vegetables in Austria. It is located at the North-Eastern border of Vienna (Lat. 48.20°N, Long. 16.72°E) in the federal state of Lower Austria and has a total size of app. 900km². Around 75% of the area is used for agriculture - this is the highest value in Austria. Around 30% of the agricultural area is irrigated.

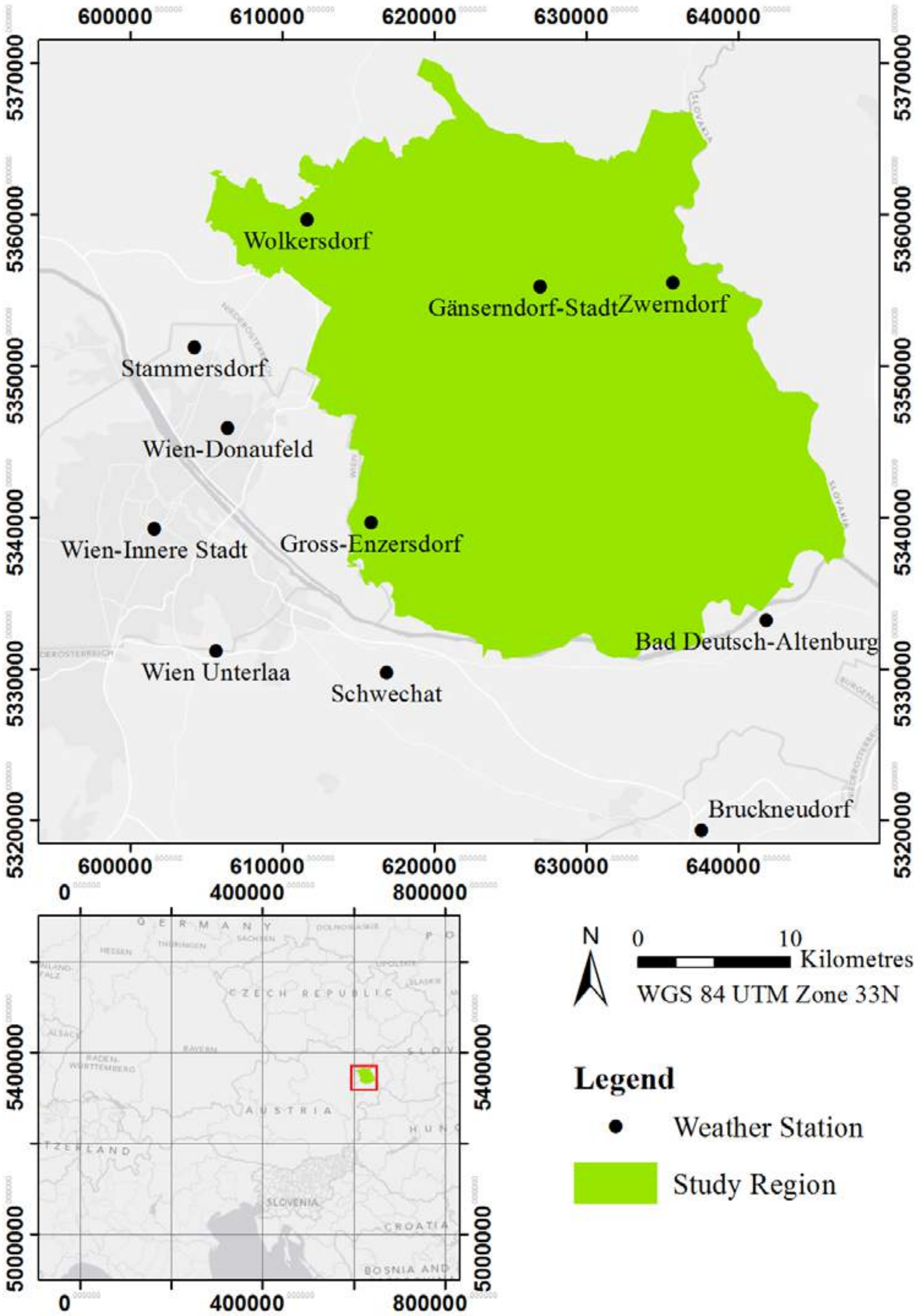

Figure 1: Map of pilot area Marchfeld in Austria

3.1.2 Farm structure

The farm structures are large and economically viable compared to other areas in Austria. There are 884 farms with more than two-thirds (72%) professional farms where farming is the only source of income. The average size of a farm is around 55ha and there is an upward tendency towards less farms with larger areas and an increasing number of organic farms.

3.1.3 Climate

Marchfeld has a flat topography with an altitude of around 160-180m above sea level. The region is characterized by a semi-arid climate with an average annual precipitation of 500–550 mm that can drop to 300 mm making it the driest region of Austria. Precipitation during the growing season (April–September) is 200–440 mm. The average temperature is between 9-10°C and evapotranspiration is around 640mm (1993, Dobesch).

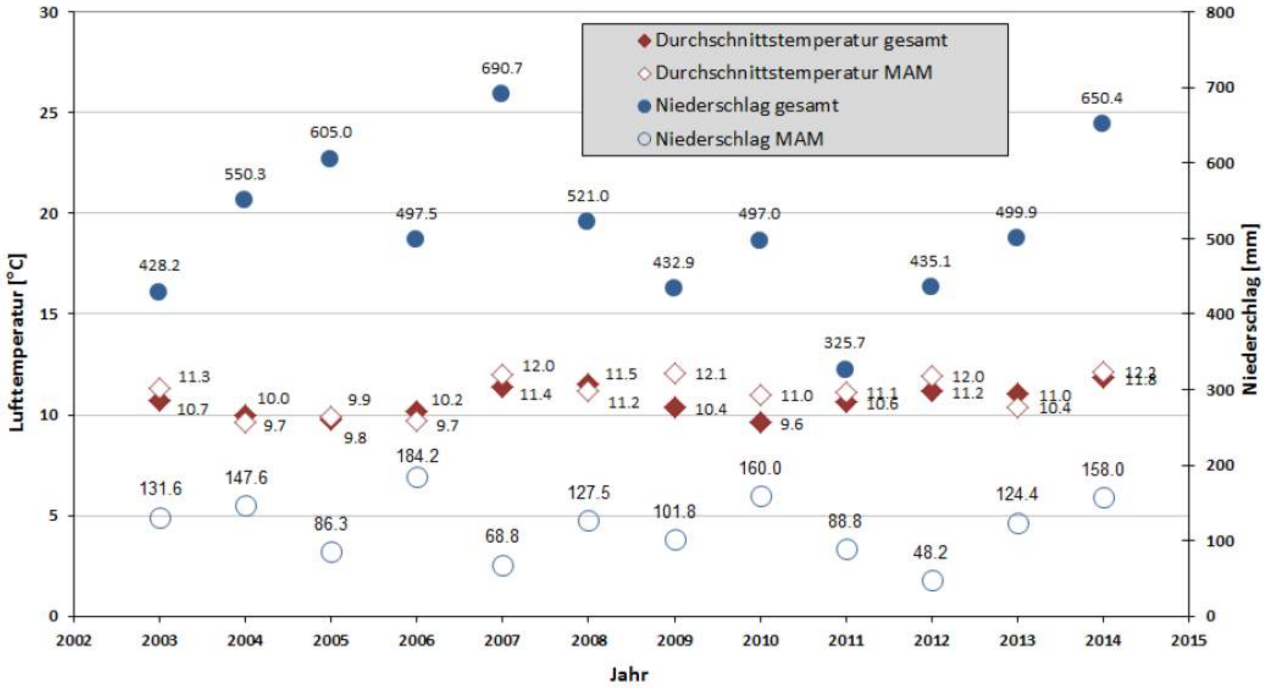

Figure 2: Climate chart of one weather station in Marchfeld; location: Rutzendorf (Source: mubil.boku.ac.at/wp-content/dokumente/MUBIL_V_Abschlussbericht.pdf, , last access 3/31/2016)

3.1.4 Groundwater and soil

Marchfeld features one of the largest continuous groundwater bodies in Austria with a volume of more than one billion cubic meters. The aquifer is composed of sands and gravel, which settled during the last ice age about 10.000 years ago. The depth of the groundwater body ranges from 2-15 meters below the surface. The thickness of the water body varies from only few meters to up to 80 meters.

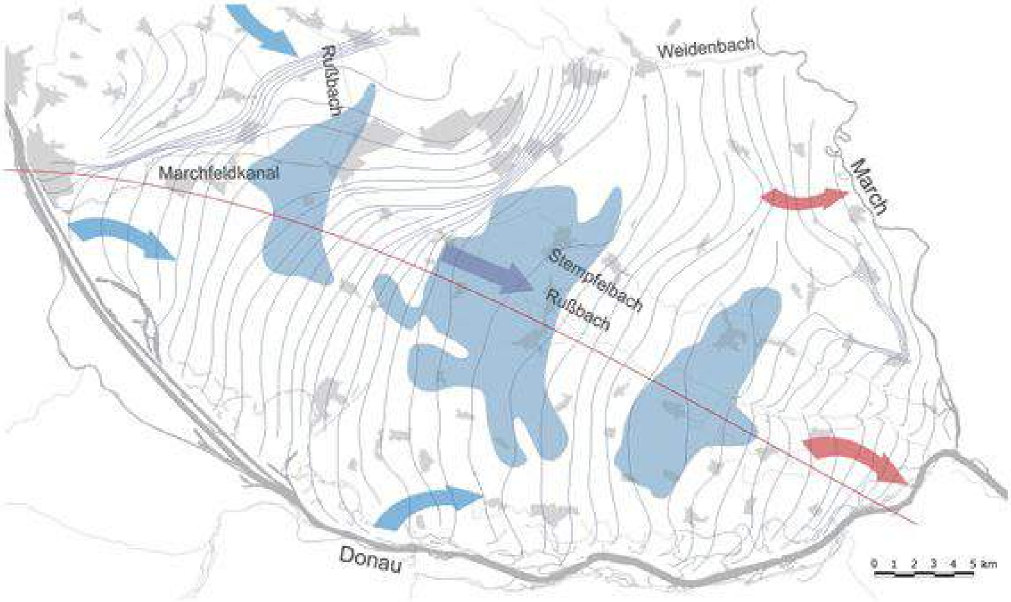

Figure 3: Groundwater body and its flowing direction in Marchfeld (Source: www.marchfeldkanal.at)

A canal ("Marchfeldkanal") was built from 1986 to 2004 to improve the groundwater conditions –quality and quantity – in the Marchfeld. In addition, the channel serves as flood protection, revives old watercourses and provides local recreation possibilities. The water from the canal diverted from the Danube is used for recharge of the groundwater and – to a lesser extent – directly for irrigation.

The dominant soil types are Chernozem and Fluvisol, based on the Food and Agriculture Organization (FAO) World Soil Classification. The general soil conditions are characterized by a humus-rich A horizon and a sandy C horizon, followed by fluvial gravel from the former river bed of the Danube.

3.2 Main Challenges

3.2.1 High nitrate levels in groundwater

A survey of water samples taken in domestic wells between 2003 and 2014 showed highest groundwater pollution levels with nitrate (above the legally maximum permissible value of 50mg/l) in the project region Marchfeld (see Figure 4 below). Some districts (e.g. Leopoldsdorf, Eckartsau, Orth) in the project area are not connected to the centralised water supply system, where the service providers have to guarantee to supply water below the legal threshold values. The groundwater body in Marchfeld does not reach 'good chemical status' as demanded by the European Water Framework Directive (WFD).

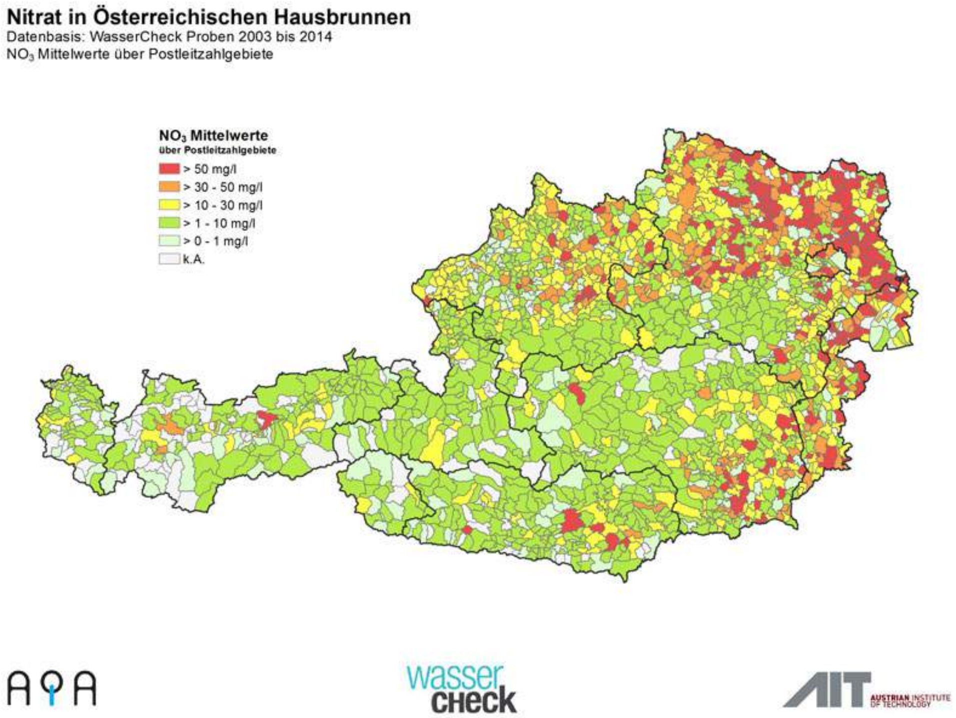

Figure 4: Average values of NO_3 of water probes for single households, Source: http://derstandard.at/2000015486212/Erhoehte-Nitratwerte-in-vielen-Hausbrunnen)

3.2.2 Fluctuating groundwater level

The groundwater level in the area is highly fluctuating. Farmers use in summer around 25 million m³ groundwater for irrigation (around 60% of the total water demand of the area), but also on a long-term basis the water levels are not constant. High groundwater levels after years with higher precipitation cause flooding of cellars and in years with lower groundwater levels complaints about the high water consumption of agriculture dominate the public discussion. Until the 1970s the area was known for its high groundwater level, but with the industrialization of agriculture and the rising demand for irrigation the groundwater levels fell significantly. High precipitation in the 1990s led again to a higher groundwater level and in houses built during the period of low groundwater cellars were flooded. (Source of information: www.marchfeldkanal.at)

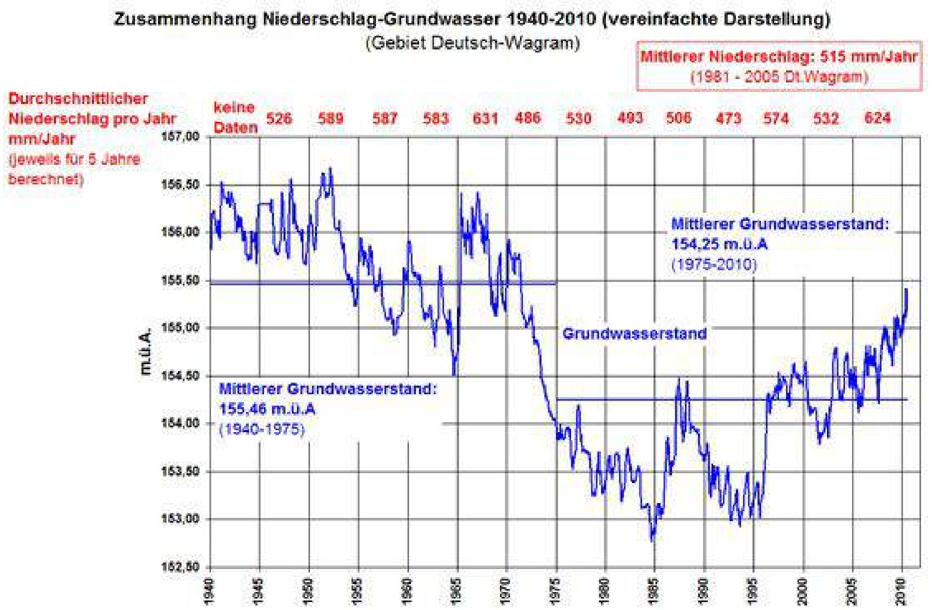

Figure 5: Groundwater level in Marchfeld between 1940 and 2012

3.3 Major crops

The main crops are winter wheat (17.034 ha), vegetables (6.262 ha), sugar beet (5.940 ha) and maize (4.925 ha). Single plots have a size of around 5 ha with a variability (1-20ha) and are generally rectangular with one narrow and one long side.

Table 7: Major crop types in the pilot area AT

	Most common crops	Total area (ha) within Pilot Area	Month of sowing / harvest (months of irrigation if applicable)	Average yield (t/ha)[1]
1st	Winter wheat	17 034	Oct – July	3.5 - 6
2nd	Vegetables (Onion, Carrots, Peas, Spinach, etc.)	6 262	Mainly spring (March/April) – Sep/Oct	Depends on the type of vegetables
3rd	Sugarbeet	5 940	April/May – Sep/Oct	45-60
4th	Maize	4 925	April/May – Sep/Oct	6-10
5th	Potatoes	2 500	April/May – Aug/Oct	25 - 35

3.4 Current practices related to water and fertilizer use

Average values of irrigation volumes and the legal limits for nitrogen fertilization of selected crops is given in Table 8Table 7.

Table 8: Maximum allowed nitrogen amounts (conventional/ if participating in environmental program ÖPUL) depending on soil type

[1] http://www.ages.at/fileadmin/AGES2015/Service/Landwirtschaft/Boden_Datein/Broschueren/SGD_6_Auflage.pdf

Crop	Max. Allowed nitrogen amounts per year [kg/ha]	Max. nitrogen amounts if farmers participate in env. Program ÖPUL [kg/ha]	Fertilizer recommendation [kg/ha] (AGES [2])	Average irrigation amounts per cropping season [mm], estimation
Sugarbeet	120 – 165	110-130	90-110	150 - 300
Potatoes	145 - 195	130-150	110-130	100 - 150
Peas	100-130	70	0-60	50 - 100
Onion	145 – 205	130-163		100 - 200
Durum wheat	145 – 195	130-150	110-130	Usually not irrigated
Winter wheat	145 - 195	130-150	110-130	Usually not irrigated
Maize	155 - 210	140-160	120-140	100 - 200

There are no official restrictions in the water use except of the water rights of the single wells. Water meters are not obligatory and there is no monitoring of the actually used water. Irrigation amounts have to be noted in a "water book", but are not strictly controlled.

3.5 Water supply and wastewater treatment

Groundwater is the main source of water for agriculture, urban and industry. For irrigation, also surface water from small rivers is sometimes used (Russbach, Marchfeldkanal, Stempfelbach, Obersiebenbrunner Kanal), and only if available.

Groundwater is not drinkable due to high nitrate values (> 50mg/l). Local nitrate removal is done by a bank filtration plant (near Marchfeldkanal) and by a biological treatment plant (Obersiebenbrunn for 30.000 PE (population equivalent)). A local water provider supplies the majority of communities centrally. Only few communities in the Southern part of Marchfeld have on-site supply by single wells (see Figure 6).

There are 16 communal wastewater treatment plants in the area with a capacity of >2000 PE each, single houses which are not connected to a sewer have on-site solutions (mainly septic tanks, which are emptied by a local service provider).

The Danube and the Moravia River Basin are the main contributing rivers in the area.

[2] http://www.ages.at/fileadmin/AGES2015/Service/Landwirtschaft/Boden_Datein/Broschueren/SGD_6_Auflage.pdf

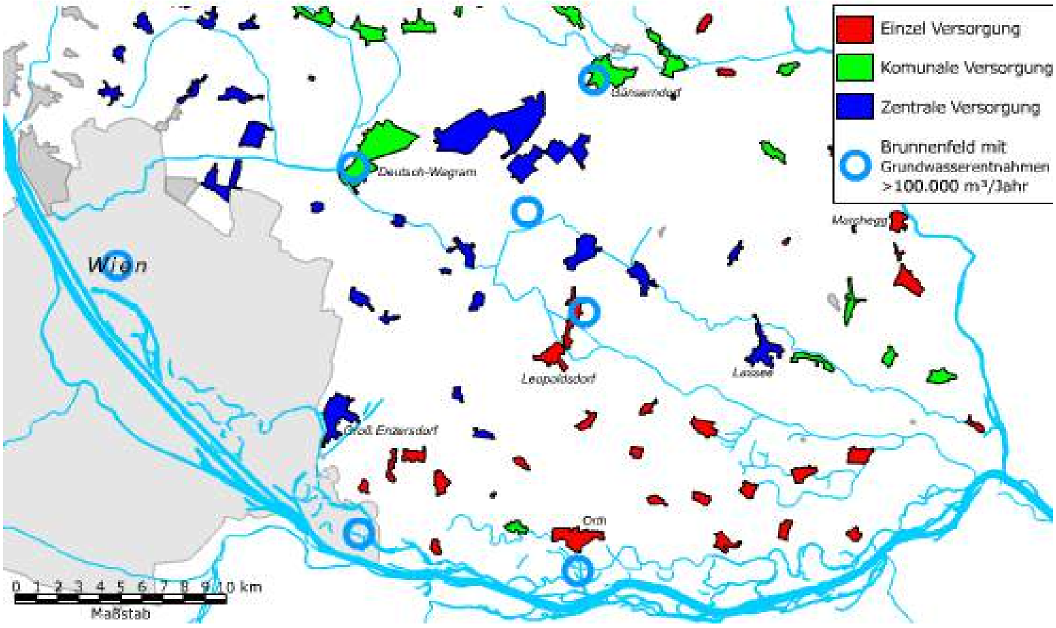

Figure 6: Areas not supplied by the centralized water provider (in red), Source: www.marchfeldkanal.at)

3.6 Irrigation infrastructure

Irrigation is typically performed with fixed pipes and sprinklers. Also self-driving irrigation machines (irrigation guns) are more and more used. Only few farms have center pivot systems and drip irrigation is only practiced for permanent crops (e.g. fruit trees) (http://fachverband-feldberegnung.de/pdf/niederoe.pdf, last access 3/31/2016). Diesel or electric pumps usually pump the water for irrigation from individual wells. There are nine water cooperatives in the area, which use communal irrigation networks.

3.7 Main policies relevant for rural development

3.7.1 Österreichisches Programm für ländliche Entwicklung 2014 – 2020 (LE14-20)

The Austrian Program for Rural Development (LE14-20) was approved by the European Commission in December 2014. Based on the Program guidelines to implement the single measures on national level were released, in which the details of funding are regulated. ÖPUL and LEADER are part of the LE14-20.

3.7.1.1 ÖPUL – Austrian Environmental Program

The Agro-environmental program ÖPUL 2015 is part of the LE14-20 program and contains environmental-friendly management measures for which individual farmers get subsidies.

Measures contain e.g. rules for intercropping, reduced fertilization, blocking periods for fertilization, planting of rare crops, and organic farming.

Participation is nationwide voluntary possible and the maximum award for agriculturally used areas is 700€/ha.

3.7.1.2 LEADER

Another part of the LE14-20 is the establishment of local activity groups that have the main working focus on rural development. In Marchfeld, the LAG Marchfeld was established. It covers the entire Marchfeld and it already published the development program for the period 2014-20 (http://www.regionmarchfeld.at/blog/wp-content/uploads/2014/07/LES-Phase-2_V10_oeffentlich1.pdf).

The focus is on the increased added value within the region (tourism, agriculture, alternative energy), increased awareness for environmental protection and biodiversity and improved infrastructure (mobility, local supply, education). There is a strong focus on non-agricultural measures.

3.7.2 Nitrate directive

The nitrate directive was implemented into national law in 2008 and is implemented nationwide which is an exception in the FATIMA pilot areas as in all other countries Nitrate Vulnerable Zones (NVZs) were determined.

The law determines the maximum amount of nitrogen that can be applied to specific crops depending on the soil conditions and preceding crops. It also sets up special rules for the storage of manure, fertilization on frozen soils and sloppy terrains.

The most recent version of the law of 2012 can be downloaded here: http://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserrecht_national/recht_gewaesserschutz/APNitrat2012.html (last access 3/31/2016, 1:36 PM)

3.8 User requirements

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2

During the 1st Plenary meeting in October 2015 in Albacete (Spain) the institutional stakeholder AGES (Austrian Agency for Health and Food Safety) represented by Dr Adelaide Spiegel was present and presented the requirements from an institutional perspective.

AGES is a company of the Republic of Austria, owned by the Austrian Federal Ministry of Health and the Federal Ministry of Agriculture, Forestry, Environment and Water Management. The activities undertaken by AGES in the area of agriculture encompass the registration and control of agricultural supplies (seeds, plant protection products, feedstuffs, etc.), food inspections, the prevention and control of animal diseases and infectious diseases in humans, as well as the recommendation of fertilizer amounts.

The fertilizer recommendations are based on long-term trials. FATIMA can help to improve the recommendations and adapt them better to the highly variable soils to avoid N losses to the water and improve the economic efficiency of farmers.

3.9 Campaign plan

3.9.1 General purpose of the campaign

The general purpose of the campaign is to develop and calibrate methodologies to map water and nutrient requirements and to set-up the web-GIS for data evaluation, dissemination and use by local farmers and institutional users.

A first set of FATIMA products shall be developed and discussed with a small group of users at field (farmers) and at governmental and advisory level (AGES).

3.9.2 Field trials

3.9.2.1 Purpose

The purpose of the field trials is to establish a ground truth database for calibration and evaluation of EO satellite products (maps of water/nutrient requirements and yield).

3.9.2.2 Design

The Austrian Pilot Area experimental field trial is focussing on the impact of different N-fertilization rates.

In 2015 AGES starts with four small plot field trials, which were integrated in long-term trials:

- Two field trials (located in the *Haringsee* and *Breitstetten* municipalities) in the Marchfeld with winter wheat at different N fertilization stages of 70, 95, 120 and 145 kg N/ha were tested;
- A long-term tillage trial (conventional ploughing, reduced tillage, minimum tillage/conservation agriculture) in Fuchsenbigl with maize at fixed 120kg N/ha was analysed;
- A compost trial with four mineral N variants (0, 40, 80 and 120 kg mineral N) and four different kinds of compost (bio waste, green waste, manure and sewage sludge compost).

In 2016 and 2017 three commercial plot experiments (plot size 90x90 m) will be established with four mineral N variants (including 0, medium, optimum) with 3 replications, respectively, all at P, K fixed at optimum. Each year winter wheat, maize and sugarbeet crops will be grown.

See D3.3.1 for the tested parameters.

3.9.2.3 Results 2015

The tests carried out at the two field trials (*Haringsee* and *Breitstetten*) in the Marchfeld with winter wheat included established methods of soil analyses (e.g. mineral N in the spring and after the harvest) and plant tests (*SPAD* readings) as well as newly developed – by *BOREALIS* (local fertilizer provider) - *N Pilot* measurements at different growth stages to determine the actual N status (and demand) of the crop. The N_{min} and *N Pilot* measurements in early spring (March and April) did not show significant differences between the fertilization stages at both sites. In *Breitstetten*, the two *N Pilot* measurements in May (11th and 27th) and the *SPAD* measurement on May 27th showed statistically significant differences at least between the lowest (70 kg N) and the highest (145 kg N) N fertilisation rate. As expected, winter wheat yields increased with increasing N fertilization rates at both sites. Crop measurements (*SPAD*, *N Pilot*) at the end of May and crop yields showed - positive - significant correlations, especially at the site *Breitstetten*. Further chemical soil parameters and the N concentrations in the crops are currently analysed.

3.9.3 Description and purpose of the Earth Observation campaign

3.9.3.1 Purpose

The purpose of the EO campaign (using Sentinel-2 and Landsat-8 data), which will take place contemporaneously to the field trials/experiments, is to acquire EO satellite data 1) to develop and calibrate models and 2) to obtain maps of nutrient and water requirements and to produce maps of yield (end of season) for evaluation with users.

Also maps of nutrient and water requirements at higher spatial resolution (WV-2 at 2 meter pixel size) will be produced at selected dates of strategic importance in crop phenology.

3.9.3.2 Design

The experiment and demonstration will require a basic set of 12-15 high spatial resolution satellite images over the crop growing season (about 6 months: April-September). Bi-weekly images (every 14 days) will needed during rapid growth phases, while for the rest of the time monthly images are sufficient. Consequently, the basic EO data requirements for the campaign can be summarized in a revisit time of 14 days and a spatial resolution of 10-30 m pixel size. Satellite images acquired in the visible, near and short-wave infrared will be used. Various satellite data providers satisfy our requirements (e.g. Landsat-8, SPOT, Pleiades, Sentinel-2 and WorldView-2). The choice of the EO data will be based on a trade-off between EO data availability and cost, and ability to describe crop growth cycles with adequate spatial resolution.

A first estimation of the availability of satellite acquisitions over the test site was carried out using a probability map created for the Sentinel-2 mission planning. This constellation of 2 satellites would be able to acquire cloud-free images with a revisit time of 5 days in areas with clear-sky conditions (as in Southern Europe during the summer) and of 15-30 days in cloudy areas. Based on this estimation, complete cloud-free images would be available every 10-15 days over our test site.

Ground-based reflectance measurements will complement the EO satellites mainly for radiometric and atmospheric correction.

3.9.3.3 Results (Summer 2015)

The EO/satellite component of the 2015 campaign (April-July) was based only on ground measurements of reflectance using an ASD field spectro-radiometer in the spectral range 350-2500 nm, mainly because of the small size of experimental fields. The reflectance measurements were used to test strength of different relationships between vegetation indices (VI) and chlorophyll measurements at plant level. Various VIs were derived using the spectral bands of the Sentinel-2 satellites and we are currently processing the data.

3.10 Ongoing / past activities

3.10.1 EO4Water (Earth Observation for rural water management)

EO4Water (2012-2014) and EO4Water-2 (2014-2015) are two research projects related to water resource management that have been implemented in the pilot area. Within the projects, an advisory service was developed that provides to farmers a decision support tool for irrigation management. It uses high spatial resolution satellite images to estimate crop evapotranspiration and an online geographic information system (web-GIS) to deliver maps to farmers. The system also includes a mobile application for data delivery and collection of ancillary data (e.g. crop type, irrigation and fertilizer applications) from farmers.

Within the projects, various field experimental and demonstration activities were organized with 30+ participating farmers with 358 irrigation units, covering 1780 hectares of the Marchfeld (area in the eastern part of Austria). The network of users developed in these two projects will be also involved in FATIMA development and demonstration activities.

3.10.2 AGES Long-term field experiments

3.10.2.1 Field trials to evaluate soil analysis methods and fertilization recommendations

In 1976 field trials testing N, P, K and Mg mineral fertilization on four (three for Mg) levels were laid out at experimental sites in Lower Austria (three in the Marchfeld) with a randomised block design and 3 replications at sites different in soil and climatic conditions. These field experiments are the basis to evaluate soil analysis methods, especially for plant-available nutrients and their thresholds and serve as a basis for the Austrian fertilization recommendations.

3.10.2.2 Effects of different tillage treatments

In 1988 a field experiment was designed in Fuchsenbigl (Marchfeld) to study the effects of different tillage systems (conventional, reduced, minimum) on chemical, physical and microbial soil parameters (e.g. Spiegel et al., 2007, Tatzber et al., 2015). The tillage treatments were investigated in plots sized 12 m x 60 m (720 m2) and arranged in a block design with three replicates:

3.10.3 HORIZON 2020 project "LANDMARK" (2015-2019)

According to the work description, LANDMARK is a pan-European multi-actor consortium of academic and applied research institutes, chambers of agriculture and policy makers that will develop a coherent framework for soil management aimed at sustainable food production across Europe. The LANDMARK proposal builds on the concept that soils are a finite resource that provides a range of ecosystem services known as "soil functions". Functions relating to agriculture include: primary productivity, water regulation & purification, carbon-sequestration & regulation, habitat for biodiversity and nutrient provision cycling. Trade-offs between these functions may occur: for example, management aimed at maximizing primary production may inadvertently affect the 'water purification' or 'habitat' functions. This has led to conflicting management recommendations and policy initiatives. LANDMARK will develop a coherent scientific and practical framework for the sustainable management of soils.

3.10.4 ACRP project A-CC ("Austrian Carbon Calculator"), 2012-2015.

According to final project report (Sedy et al., 2015, unpublished), the Austrian Carbon Calculator aimed at building a knowledge base for the potential of soil carbon sequestration in arable soils for Austria with regard to different soil management practices including crop rotations better adapted to climate change. In this project a soil carbon model (CCB, Franko et al., 2011) was adapted and applied in two different agricultural production regions, among them the Marchfeld; to assess humus reproduction and to predict soil-carbon dynamics for future decades in case of unchanged management or for changed/better adapted management for single sites and regions under climate change.

3.10.5 CATCH-C ("Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health"), 2012-2014.

Within the EU project CATCH-C we aimed to analyse the effects of different agricultural practices not only on crop productivity, but also on soil quality indicators (e.g. soil organic carbon (SOC)) and climate change indicators (e.g. CO_2, CH_4, N_2O emissions), through an analysis of available European data sets and associated literature, mainly from long term experiments. Data were also derived from AGES Long-term experiments in the Marchfeld.

3.11 Pictures

Figure 7: Maize field in northern Marchfeld

Figure 8: Irrigation pipes laid out

Figure 9: Irrigated soya field

Figure 10: Rapeseed field

3.12 References

Dobesch, Hartwig (1993) Die Abschätzung der Regionalverdunstung in Ostösterreich, in Ergebnisse österreichischer Aktivitäten im International Hydrologischen Programm (IHP) 1981-1990, Band 14,p.71-80, Wien, 1993, http://www.zobodat.at/pdf/ArchivLagerst-GBA_14_0071-0080.pdf, last access 31.03.2016, 11:30 AM

Franko, U., Kolbe, H., Thiel, E. and Ließ, E., 2011. Multi-site validation of a soil organic matter model for arable fields based on generally available input data. Geoderma 166, 119–134.

Spiegel H., Dersch G., Hösch J., Baumgarten A., 2007. Tillage effects on soil organic carbon and nutrient availability in a long-term field experiment in Austria. Die Bodenkultur 58, 47–58.

Tatzber M., Schlatter N., Baumgarten A., Dersch G., Körner R., Lehtinen T., Unger G., Mifek E., Spiegel H. (2015) KMnO4 determination of active carbon for laboratory routines: three long-term field experiments in Austria. Soil Research 53, 190–204. http://dx-1doi-1org-1scopus.pisces.boku.ac.at/10.1071/SR14200

4 Dehtáře (Czech Republic CZ)

The fields in Dehtáře in the central Czech Republic are not irrigated, which is a special feature of this case study compared to all other pilot areas. They are even tile-drained by a drainage system that was established in the 1970s and is partly not functional anymore leading to the build-up of wet zones in the lower parts of the hilly area. Due to the drainage network, excess of nitrogen reaches the water bodies fast and leads to high nitrate values in surface water. Dehtáře is located in the catchment area for the water supply of Prague and therefore designated as a vulnerable zone. The main crops are cereals (winter wheat, spring barley), winter rape, potatoes and red clover.

In this pilot area, FATIMA can help to upscale VRT and assess how precision farming can contribute to minimize the impact of fertilization on water quality by producing maps of requirements and yields.

4.1 Overview

4.1.1 Geography

The pilot area Dehtáře (Figure 11) is situated in the south-west Bohemo-Moravian Highland (Czech Republic), at 49°28´ N – 15° 12´ E, close to Pelhřimov town. The experimental site was established to study the linkages between land use and management in various geomorphological zones and water quantity and quality dynamics.

Dehtáře has an area of 59.6 ha, with tile drained areas occupying 19 ha (~32%). The catchment area is mainly agricultural land (89.3%). Minor forested areas (3.3%) lie at its north-western and northern borders. Grassland (20.3%) covers the southern part of the catchment, as well as the adjacent lowest lying south-western area, which is tile-drained. The remaining area (69%) is arable land, which is used mainly for production of cereals. The catchment geomorphology belongs to the erosion-accumulation relief type. The altitude ranges between 497 and 550 m.

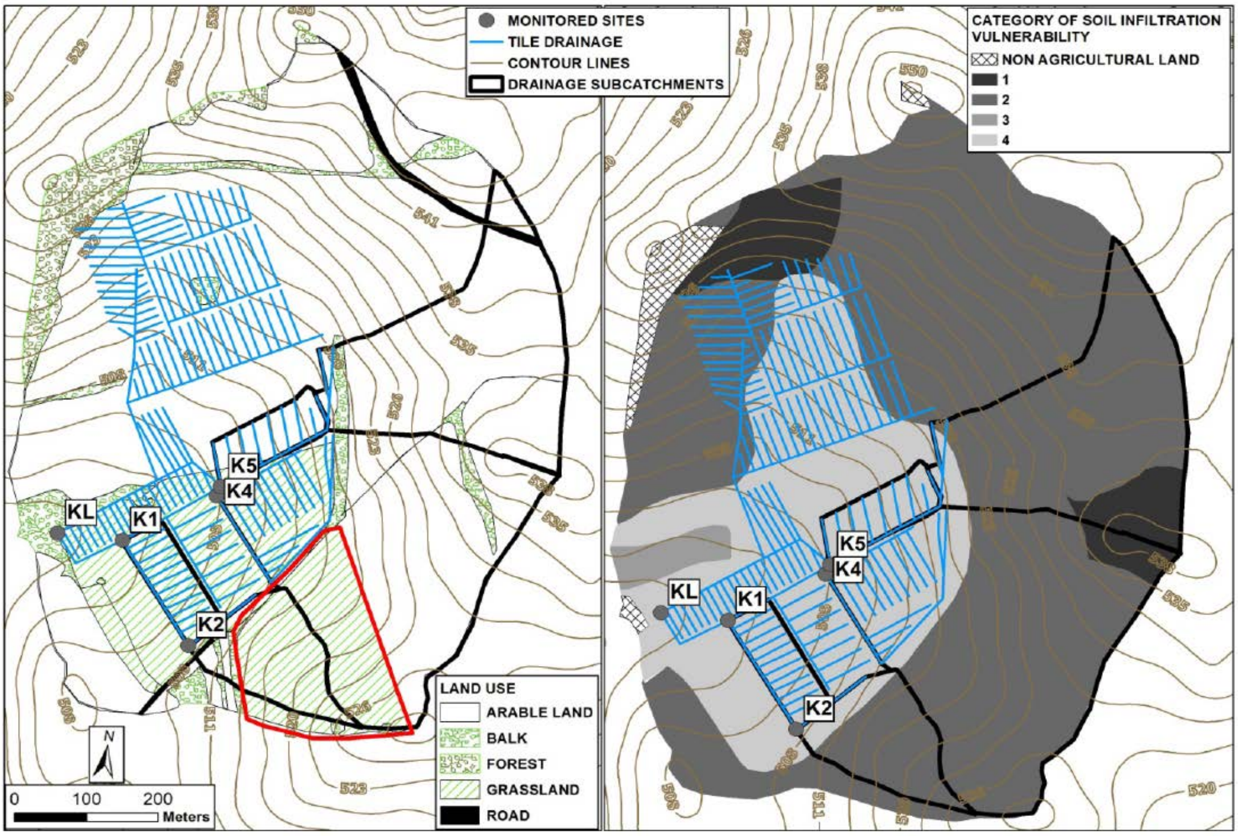

Figure 11: An overview map of the experimental catchment Dehtáře (above). Red encircled is the area experimentally grassed in 2007, location of Dehtáře in the Czech Republic (below).

4.1.2 Farm structures

Agricultural land within the Dehtáře catchment is managed predominantly by a cooperative KOJČICE. The cooperative was founded in 1992 and has sixty employees. It operates on 1 300 ha of arable land and 300 ha grasslands. Kojčice uses a classical, locally typical agricultural management system – crops rotation (5-7 years), cattle farming, using of cattle and green manure.

The average area of agricultural land, on which a farm operates in this region, is between 500 – 2500 ha. An average field has a size of around 5ha and up to 5% of the parcels are smaller than 1ha.

4.1.3 Groundwater and soil

The catchment hydrogeology, typical for this region, is characterized by shallow aquifers (with groundwater table in the discharge zone lying at 0.2–1.5 m), occurring in Quaternary deposits, in the weathered zone of the bedrock and in its fissures and faults. The bedrock is a partially migmatized paragneiss. Quaternary deposits are slope sands and bottom loams, reaching a thickness of 1–2 m. The bottom loams usually act as aquitards and have their own phreatic groundwater table, partially recharged from the atmosphere, so that the water from below mixes in them with the water from above.

The dominant soil types according to WORLD REFERENCE BASE FOR SOIL RESOURCES 2006 are Haplic Cambisols in the recharge and transient zones. These soils are light, shallow and stony (the thickness of the soil profile being only 30 cm in some parts) sandy loams and loamy sands. Haplic Stagnosols, Haplic Gleysols, Fibric Histosols and Stagnic Cambisols are typical for the discharge and the discharge/transient zones. Medium-deep sandy loams dominate in the lower parts of the slopes, while deep loams are most typical for the catchment bottom. A soil map is shown in Figure 12.

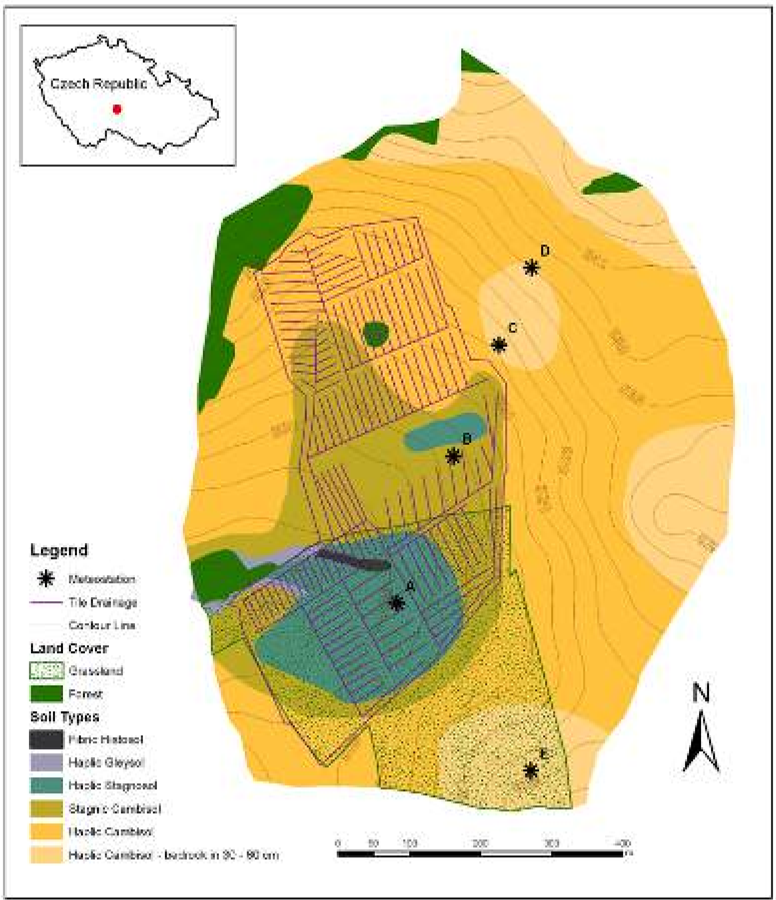

Figure 12: Soil map of Dehtáře with drainage lines and location of weather stations

The tile drainage (still mostly functioning) was laid in 1977 in the western, lower part of the catchment (see Figure 12). The average slope of the drained land is about 5%. The spacing of lateral drains is either 13 or 20 m.

4.1.4 Climate

The local climate is classified as moderately warm. The average annual total precipitation is 660 mm and the average air temperature is 7.0°C. Evapotranspiration is 450-500 mm during the growing period.

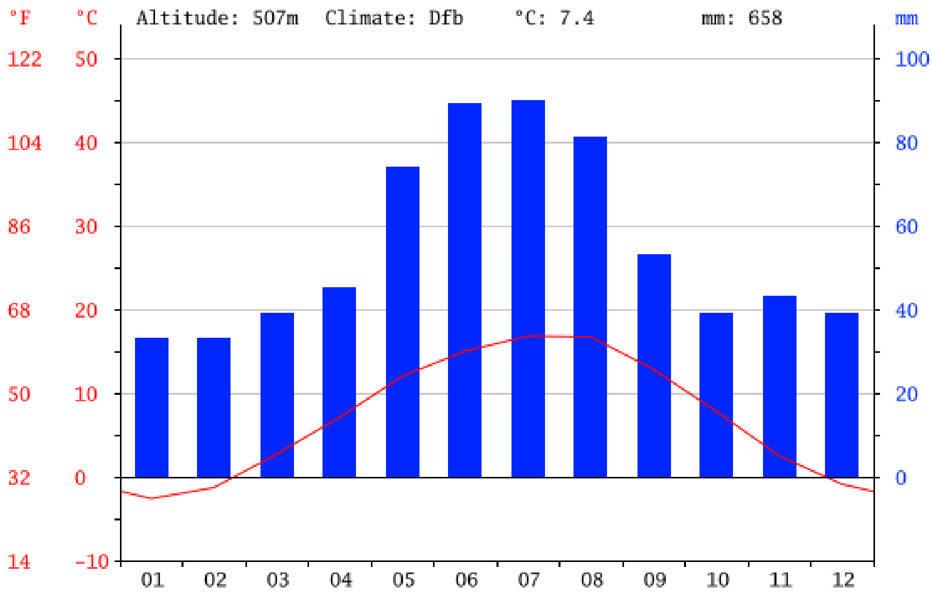

Figure 13: Climate chart of Pelhřimov (Source: http://en.climate-data.org/location/48983/)

4.2 Main Challenges

- Excessive and homogeneous use of fertilizer with a little regard to different yield potential of different fields, resulting in nutrient and pesticide enrichment of nearby water bodies (mainly nitrogen and pesticides, to a lesser extent phosphorus)
- Land and soil degradation (dehumification, soil erosion, soil acidification, soil compaction)
- Worsened status and functioning of land drainage (underground tile drainage) due to neglected maintenance (a vast and serious problem of Czech agricultural land, associated with the issue land owner / tenant, coming from the socialistic era)

4.3 Major crops

Average values of irrigation volumes and the highest permitted nitrogen amounts of selected crops are given in Table 9 and in Table 10.

Table 9: Major crop types in the pilot area CZ

	Crop	total area (ha) within Pilot Area	month of sowing / harvest (months of irrigation if applicable)	average yield (kg/ha)
Largest area	Red clover	40	April/May/ July/September	25 000
2nd largest	Winter wheat	40	September/ July-August	6 500
3rd largest	Winter rape	40	August/ July	3 900
4th largest	Potatoes	15	April/ September	40 000
5th largest	Silage maize	7.5	April-May/ September-October	35 000
6th largest	Spring barley	0.5-5	April/ August	4 500

4.4 Current practices related to water and fertilizer use

The fields in Dehtáře are not irrigated, which is special feature of this case study compared to all other pilot areas. A drainage system was built in in the 1970s. It features some problems as water logging occurs in some lower parts of the area.

Legal limits for fertilizer application are defined in the nitrate directive. The nitrate directive is tackling vulnerable zones (NVZ; see Figure 14) where groundwater and surface water show high nitrate levels or have a high risk of eutrophication (Martinkova 2010). Dehtáře is located within the NVZ as it is located in the watershed of the water supply system of Prague and Central Bohemia. In the Czech Rep., the total amount of N applied in fertilizers originated from livestock production within NVZ for is up to 170 kg N/ha/year as an average for the whole agricultural land managed by a farm.

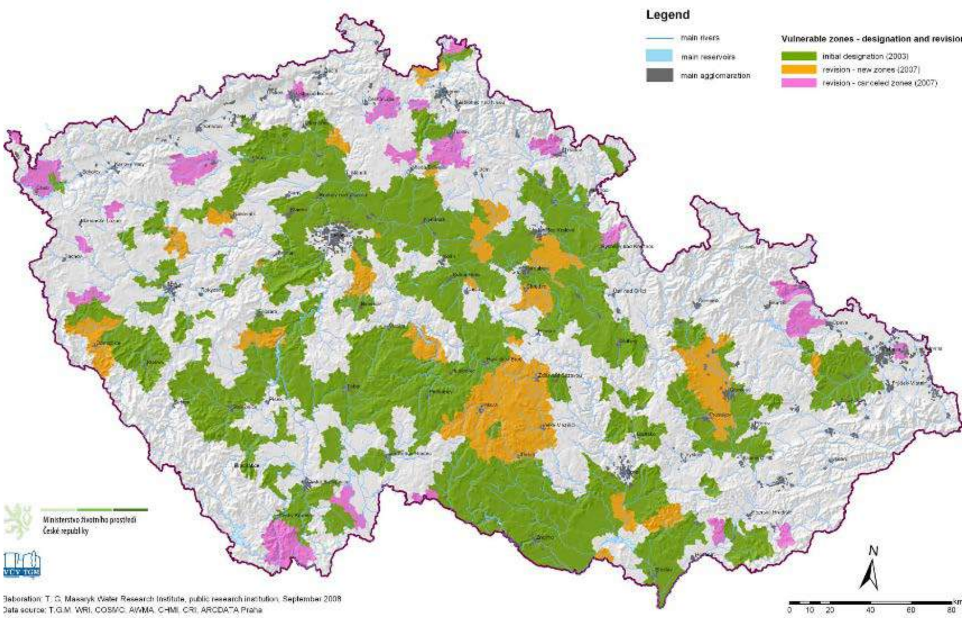

Figure 14: Vulnerable zones in the Czech Republic, only green and orange areas (Source: http://www.clrtap-tfrn.org/webfm_send/281, last access on 3/31/2016, 1:36 PM)

Table 10: Average fertilizer application and irrigation amounts

Crop	Average fertilizer application (kg N per ha; organic or mineral; solid or liquid)	Average irrigation amounts per cropping season [mm]
Red clover	0	No irrigation
Winter wheat	140 (mineral)	
Winter rape	180 (mineral)	
Potatoes	200 (autumn - cattle manure) +100 (spring – mineral)	
Silage maize	120 (mineral)	

Spring barley	90 (mineral)	

4.5 Water supply and wastewater treatment

Water from Dehtáře catchment (drainage water and groundwater) is being used as a source of fire-tank, located nearby the catchment. Dehtáře is located within the Želivka river basin with the largest Czech surface drinking water reservoir, which supplies with potable water Prague and several other towns and regions. Dehtáře is situated in the Nitrate Vulnerable Zone. The water for local use is supplied locally by wells and the wastewater from surrounding villages and dwellings is disposed to septic tanks, but both types of infrastructure are not located within the pilot area.

4.6 Irrigation infrastructure

There are no irrigation activities in the pilot area.

4.7 Main policies relevant for rural development

4.7.1 Nitrate directive

The nitrate directive was incorporated into Czech law in 2001. It encompasses the following main actions:

- Determination of periods with prohibition of fertilizing
- Limitation of fertilizer application based on the N needs of single crops
- Limitation of input of organic nitrogen into soil
- Rules for storage of fertilizers and manure
- Rules on rotation of crops, counter-erosion measures
- Guidelines for farm management near water courses

4.7.2 GAEC (Good Agricultural and Environmental Status)

The GAEC is a national environmental program, which restricts tillage, crops, etc. to diminish soil erosion and preventing impairment of water quality. It tackles soil erosion on sloped agricultural land by the implementation of minimum measures to reduce soil loss, slowing surface run off and increase water retention in the landscape. These measures are also important for reducing flood risks and damage caused by them. Around 20% of the catchment area is threatened moderately by erosion.

4.8 User requirements

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2.

During the 1st Plenary Meeting from 7-9th October in Albacete (Spain) one farmer of the cooperative in Dehtare participated and presented the crop management issues in the region on behalf of the cooperative.

The cooperative has a size of 1 500ha, of which 1 300ha are arable land. Apart from agriculture, 600 livestock units are kept in the area. The grassland area is dedicated to the production of hay that is used as fodder. In contrast to the early 2000s when flash floods and soil erosion were a serious problem, the area experiences water scarcity during the last 5 years with not only dry summers, but also lack of snowfall during the winters.

However, diminishing soil erosion is still a challenge, due to a more fluctuating amounts and intensities of precipitation.

The cooperative KOJČICE practices traditional agriculture and applies fertilizers and soil management based on own experiences and on soil samples of the state. The annual costs for applied fertilizer sum up to 5.5 million Czech crowns (200.000€).

To reduce the costs for fertilizer and increase yields, the farmer expects from FATIMA recommendation for the specific dosage of fertilizer on the heterogeneous soils in the pilot area. The machinery is already available and will be tested in the following campaigns.

4.9 Campaign plan

4.9.1 General purpose of the campaign

To provide users (farmers) with FATIMA products (maps of nutrient & water requirements and yield) in near-real time (48 hours after satellite overpass). This includes predictions for 1 week ahead (water) / for growing season (nutrients).

4.9.2 Field trials

4.9.2.1 Purpose

- Find options for calibration & evaluation of EO products (maps of soil water dynamics, soil nutrients content, crop status and yields)
- Verify the range of soil physical, and soil N spatial variability and N-input sensitivity
- Propose field trial design (stripes of different fertilizer inputs, field sensors placement scheme)
- Check option for available field VRT machinery (farm own/hired machines)
- Consider the basis for upscaling the field / plots scale results

4.9.2.2 Design

The design considers two variants

A) differentiated fertilizers application (by VRT machines) and

B) standard crop management

It is further based on various other factors

- <u>Tramlines direction</u> (machine field tracks – usually the same pattern every year for different crop) – machine working range 9 + 9 m = 18 m
- To have <u>two pixels (30x30 m) within one variants (however, we expect to use also higher spatial resolution images as e.g. from Sentinel-2)</u>
- Both variants <u>capture soil heterogeneity</u> in similar range
- Both variants are <u>partially tile</u>-drained
- Both variants are having the <u>same crop</u> in the years 2016 - 2017

Based on the above listed factors, two strips have been selected:

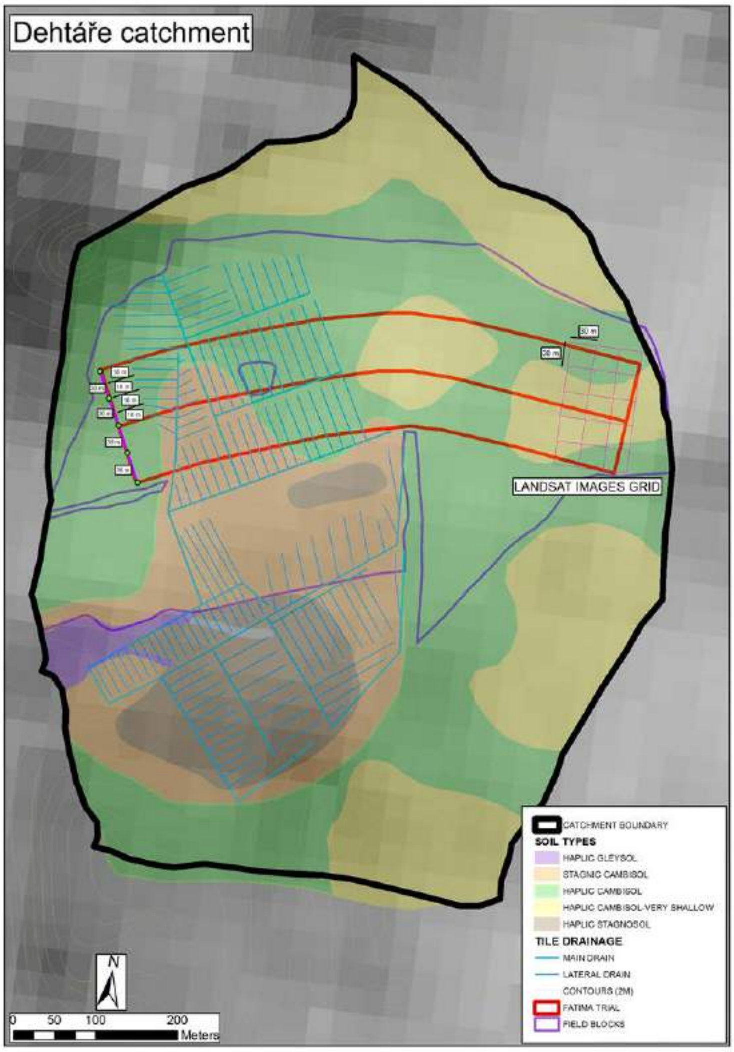

Figure 15: Selected stripes for field experiments for 2016/17 (in red)

The strips have a width of 72m (18 m within one machine working width; four widths in one strip) and 3-6 soil moisture sensors and 3-6 suction head sensors (all wireless) will be installed in each of them. Further, soil lysimeters will be installed in each soil type and variant to collect soil leachate.

4.9.2.2.1 One intensive monitoring plot (commercial production plots)

Intensive monitoring in commercial production plots:

- soil sampling & analysis (2 dates/year);
- water sampling & analysis (suction cups, lysimeters, 8-10 dates/year)
- crop biomass & nutrient content sampling (3 dates/year);
- yield spatial monitoring (end of growing season);
- crop phenology;
- fertilizer applications;
- precipitation & ET0 (continuously/monthly).

Sampling locations are determined from analysis of EO images of heterogeneity.

4.9.2.2.2 Two - three extensive monitoring plots (all commercial production plots).

Extensive monitoring in commercial production plots managed either by the cooperative Kojčice or on other places (Kopaninský stream catchment). Here, schedules of crops and agricultural management will be acquired several years back in accordance of available satellite / plane images. Further, soil properties defined by soil GIS database and specified by soil survey will serve as a base for identification of recharge zones by crop water stress method in 2017 (see Duffková et al. 2011; Fučík et al. 2015). These plots will be used to extend and upscale the knowledge, gained in the detailed field trial in Dehtáře for a larger area (hundreds of hectares, predominantly cereals).

4.9.2.1 Results

The season 2015 aimed predominantly at selecting the plots for the campaign in 2016. Until the Mid October, following items were accomplished:

I. **Harmonize project and pilot needs and abilities**

Three joint meetings of VUMOP and METCENAS with the farmers were realized (May, June, September) with presentation of FATIMA aims and goals, getting farmer´s feedback (problems, needs, expectations). Further, FATIMA quests and data sheets (D 1.1.1. and D 1.1.2.) were finalized as well as FATIMA goals and approaches were shaped for Dehtáře site. Farmers problems / needs / expectations lie in fluctuating crop yields due to significant soil heterogeneity in Dehtáře / CZ Highlands, lack or unequal distribution of precipitation which causes drought and almost useless fertilization, being applied under a undifferentiated manner. The permanent problem is water quality (nitrates, pesticides) and social issues related to agriculture (employment, tradition).

II. **Getting ready farm machinery – what is available and what is needed**

Available: Portable Autopilot RAVEN Viper 4 - automatic operation according the application map (not finished / tested yet). It is connected with machine via ISOBUS interface. It has a correction by Raven GS-Sllingshot (+/- 5-10 cm) and (or) Raven RTK-NET (+/- 2-5 cm). Option for recording of covered area, field border and work. Tractors: John Deere 7930 + Fendt 900 + ZETOR 1624; spreader (mineral fert.) RAUCH 30.1.

Needed (to be hired): Harvester with continuous yield record (already negotiated).

III. **Pilot site preparation**

Soil sampling was done in April 2015 prior potato planting (plant available nutrients, pH, CEC, SOM, etc.) and in October (predominantly for Nmin.). A design of FATIMA field trial for 2016 and 2017 was proposed (see above). Assembling satellite imagery from previous years was started as well as the design of sensors and lysimeters placement. Crop and management schedule for FATIMA was adjusted (2015 – s. barley, 2016 – w. wheat).

4.9.3 Description and purpose of EO

4.9.3.1 Purpose

- obtain maps of nutrient & water requirements every 1-2 weeks (Landsat-8 & Sentinel-2);
- obtain maps of yield (prediction & end of season);

- maps of nutrient & water requirements at higher spatial resolution at selected dates of strategic importance in crop phenology;
- analyse sensitivity of maps to different image resolution.

The maps of requirements and yield constitute the FATIMA products, which will be the basis for the FATIMA services to be provided to users.

4.10 Ongoing / past activities

4.10.1 QF 4062: Verifying the influence and extent of grassing the arable land on nitrates in surface and groundwaters as a measure for implementation of EC Nitrate Directive, 2004 – 2007, Czech National Agency for Agricultural research.

The Dehtáře site was among several other tile drained catchments, used for defining the relations among the ratio of ploughed most infiltration-vulnerable zones and flow-weighted nitrate concentrations in catchments of different scales. A strong positive relationship was found ($R^2 > 0.8$; $p<0.01$; see Fučík et al. 2015).

4.10.2 QH 92034: Recharge zones identification by water vegetation stress in selected catchments, 2009-2011, Czech National Agency for Agricultural research.

The objective of the project was the identification of recharge zones, which contribute to the quality and quantity of groundwater resources. The accelerated water movement in permeable soils of recharge zones reduces actual evapotranspiration and supports a faster formation of crop/vegetation water stress. Delimitation of recharge zones based on this theory was carried out on Dehtáře catchment by a combination of aerial photography in the infrared and optical spectrum. Evaluation of these images provided a basis for modelling of surface energy balance components and crop water stress index (CWSI). As the best indicators of vegetation water stress determining recharge zones appeared to be evaporation fraction, CWSI and surface temperature.

4.10.3 Project 3 TA04021527: Studying the causation and concentration dynamics of pesticide burden in small water courses, 2014 – 2017, Technology Agency of the Czech Republic

The aim of the project is to describe natural conditions and processes in connection with agricultural management in order to explain dynamics of selected pesticide concentrations, loads and balances in ground, subsurface and surface waters. A set of principles for a more water-friendly use of pesticides will be formulated for different catchment zones based on local soil and terrain properties, tile drainage characteristics and catchment hydrology.

4.10.4 TA02020337: Decreasing phosphorus inputs to surface and groundwaters from non-point sources by agrotechnical measures, 2012 – 2015, Technology Agency of the Czech Republic

The objective of this project is the reduction of phosphorus leaching from non-point pollution sources (agricultural land) in protection zones of water resources and eutrophication decrease in Želivka River basin. The goals are expected to be achieved by the optimized agricultural management and / or measures depending on soil conditions and terrain topography. The project's output will be a certified methodology and specialized maps using Phosphorus Index method, which will be used for completing the Plan of Lower Vltava River Basin Area.

4.11 Pictures

Figure 16: Dehtáře pilot area

Figure 17: Waterlogging in the lower parts of the pilot area

Figure 18: Dehtáře pilot area

Figure 19: Dehtáře pilot area

4.12 References

Martinkova (2010) Implementation of EC Nitrate Directive in the Czech Republic, 38th IAD Conference, June 2010, Dresden, Germany (http://www.researchgate.net/publication/265035626_Implementation_of_EC_Nitrate_Directive_in_the_Czech_Republic) (last access 27.08.2015, 11:50 CET)

FUČÍK, P., ZAJÍČEK, A., DUFFKOVÁ, R., KVÍTEK, T. 2015. Water Quality of Agricultural Drainage Systems in the Czech Republic Options for Its Improvement. In Book: Research and Practices in Water Quality, Edition: 1, Chapter: 11, pp. 241 - 262. DOI: 10.5772/59298

NOVÁKOVÁ, E., KAROUS, M., ZAJÍČEK, A., KAROUSOVÁ, M. 2013. Evaluation of ground penetrating radar and vertical electrical sounding methods to determine soil horizons and bedrock at the locality Dehtáře. Soil and Water Research 8 (3), 105-112.

ZAJÍČEK, A., KVÍTEK, T., KAPLICKÁ, M., DOLEŽAL, F., KULHAVÝ, Z., BYSTŘICKÝ, V., ŽLÁBEK, P. 2011. Drainage water temperature as a basis for verifying drainage runoff composition on slopes. Hydrological processes 25:3204-3215. DOI: 10.1002/hyp.8039.

DUFFKOVÁ, R., ZAJÍČEK, A., NOVÁKOVÁ, E. 2011. Actual Evapotranspiration from Partially Tile-drained Fields as Influenced by Soil Properties, Terrain and Crop. Soil & Water Research 6(3): 131-146.

BÚZEK, F., BYSTŘICKÝ, V., KADLECOVÁ, R., KVÍTEK, T., ONDR, P., ŠANDA, M., ZAJÍČEK, A., ŽLÁBEK, P. 2009. Application of two-component model of drainage discharge to nitrate contamination. Journal of Contaminant Hydrology 106: 3-4. ISSN 0169-7722.

5 La Mancha Oriental (Spain ES)

La Mancha Oriental is located in South-East of Iberian Peninsula on a high plateau in the Jucar River Basin. The semi-arid climate makes irrigation necessary; often nitrogen fertilizers are applied as fertigation in pivot systems. Over-extraction of groundwater and nitrate leaching has deteriorated the groundwater body. Parts of the pilot area are designated as nitrate vulnerable zones and restrictions for fertilizer rates apply. The main crops are under irrigation: vines, winter cereals, maize, alfalfa, poppy, garlic and onion; and in rainfed area vines, winter cereals and legumes.

A better knowledge about the crops water and fertilizers requirements, temporal and spatial distributed, could contribute to an improvement of the agronomic management, to better inputs (fertilizers and water) allocation and to avoid undesirable ecological and economic negative impacts derived from their overuse

5.1 Overview

5.1.1 Geography

The Mancha Oriental area is characterized by having a relatively flat surface with an average height of 650 m. It is located in the South-East of the Iberian Peninsula, at 39.7N-38.6N and 2.53W-0.9W, in the Jucar River Basin. It occupies about 10.000 km² of which more than 500.000ha are devoted to agriculture.

The total population is close to 400.000 people and the biggest settlement are Albacete (170.000 inhabitants) and La Roda (16.000 inhabitants).

Figure 20: Map of the pilot area La Mancha Oriental in Spain

5.1.2 Farm structure

The area features mainly medium to large farms with 70% of the farms being larger than 100ha. The average single plot size is 10 ha (rainfed) / 15ha (irrigated). There are around 5% of plots smaller than 1 ha. Around 10% of the farms practice organic agriculture and 7,5% conservation agriculture.

5.1.3 Groundwater and soil

The Mancha Oriental Aquifer is located in the Mancha plateau. It is a large groundwater body that is connected to the Jucar River in terms of drainage and recharge. The groundwater level lies at a depth of 60-200m.

The soil is shallow with a limestone bedrock. It is highly variable with sandy loam, loam and clay loam, often stony, but easy to cultivate and quite fertile under appropriate agronomic management.

5.1.4 Climate

The pilot area features a semi-arid climate with an annual precipitation below 350mm and an evapotranspiration of 1200mm. **It is characterized by a high variation between seasons according to the Mediterranean-Continental type. The averages temperatures vary between 5 ºC on January (coldest month) to 24 ºC July (hottest). The climatic records show an average temperature of 13.6 ºC with 2,800 hours of insolation per year. The oscillation between dry and wet years ranges from 124 mm/year to 750 mm/year.**

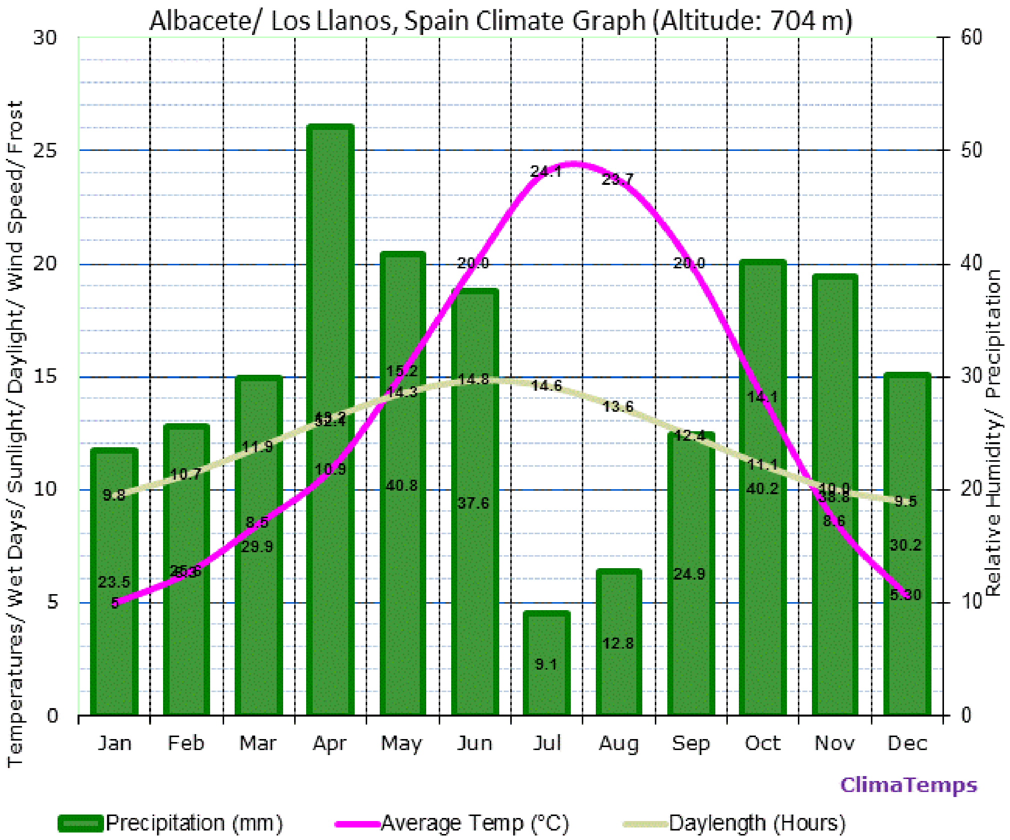

Figure 21: Climate chart of Albacete (Source: http://www.albacete.climatemps.com/, last access on 28.08.2015, 10:00 CET)

5.2 Major crops

Table 11: Major crop types in the pilot area ES

	crop	total area (ha) within Pilot Area	month of sowing / harvest (months of irrigation if applicable)	average yield (kg/ha)
Largest area	Wheat/ barley	180.000 (rainfed) 45.000 (irrigated)	Oct/Jun Dec/Jul (Feb/Jun)	1.800 (rainfed) 7.000 (irrigated)
2nd largest	Vineyard	100.000 (rainfed) 40.000 (irrigated)	Apr/Sep Apr/Sep (Jun/Aug)	8.000 (rainfed) 15.000 (irrigated)
3rd largest	Maize	14.000	Mar/Oct (Mar/Aug)	14.000
4th largest	Alfalfa	4.500	Mar/Oct (Mar/Oct) 5-6 cuttings	18.000
5th largest	Onion	5.000	Feb/Aug (Feb/Aug)	70.000
Other	Garlic Poppy Legume	4.500 4.000 30.000 (rainfed)	Oct/Jun (Oct/May) Feb/Jul (Feb/Jun) Nov/Jun	20.000 1.800 800

5.3 Main Challenges

- Aquifer depletion.
- Nitrate aquifer pollution.
- Soil degradation and desertification.
- Irrigated crops CO_2 balance

5.4 Current practices related to water and fertilizer use

The pilot area is prone to soil erosion and 80% fall under the nitrate directive which was translated into national law in 1996. It is based on the determination of vulnerable zones.

The region of Castilla La Mancha has 6 nitrate vulnerable zones and La Mancha Oriental is one of them. (http://research.ncl.ac.uk/nefg/ntoolbox/pdf/NTOOLBOX_D1-3.pdf, last access on 28.8.2015, 11:00 CET).

An action program for the area was defined in 2007 that limits for fertilizer application have been set according to crop and soil type. Nitrogen contained in irrigation water is taken into account. (http://www.asajaclm.org/publicaciones/manuales/manuales_publicacion_asaja_clm_contaminacion_por_nitratos_agrarios_.pdf, last access on 28.8.2015, 11:00 CET).

Table 12: Maximum allowed nitrogen amounts (conventional/ conserving agriculture), average application amounts and average irrigation volumes

Crop	Average nitrogen amounts, estimation [kg/ha]	Average irrigation amounts per cropping season [m³/ha]	Max. nitrogen amounts in NVZs [kg/ha] rainfed / irrigated[3]
Wheat	220	3000	60-70 / 95-110
Wine	160	1500	50-60 / 70-90
Maize	280	6000	-/ 210 - 220
Alfalfa	40	7600	0-20 / 20-30
Onion	220	5200	/ 150 - 160

5.5 Water supply and wastewater treatment

The water used in the pilot area is mainly supplied by groundwater (93%). Agriculture is the largest water consumer with a share of 89% of the supplied water being used by individual farmers and 6% by water user associations summing up to 95% of the water demand.

All aquifers in the pilot area are located within the Jucar River basin and threatened by over-extraction and feature no "good status" as defined in the WFD

(http://www.abtevere.it/sites/default/files/datisito/prb/ita/provisional_article_5_report_jucar.pdf, last access on 3/31/2016, 1:36 PM).

Even though irrigation with wastewater is commonly practiced in the area of Valencia (57% of the treated WW are reused, Salcedo 2010), this practice is not reported in Albacete.

5.6 Irrigation infrastructure

No furrow or flood irrigation, all pressurized systems.

Annual crops: central pivot (75%) and other sprinkler systems (25%)

Woody crops: drip irrigation (100%).

Due to the deep groundwater level (60-200m), electricity costs for irrigation is one of the main component of total production costs, for instance wheat up to 500€ / ha and maize up to 1000€ / ha.

5.7 Main policies relevant for rural development

5.7.1 Rural development program Castilla-La Mancha

New Rural Development Program (2015 – 2020) pending approval; main relevant policies still underway:

Promoting knowledge and improving human potential:

- Setting up of young farmers

[3] Programa de Actuación, applicable a las zonas vulnerables a la contaminación por nitratos de origen agrario en la Comunidad Autónoma de Castilla-La Mancha, ASAJA, 2007, p.16-17

- Early retirement
- Use of advisory services
- Setting up of management, relief and advisory services
- Modernisation of agricultural infrastructure (irrigation systems, precision farming equipment)

Sustainable use of agricultural land:

- Payments to farmers in areas with handicaps
- Natura 2000 payments and payments linked to Directive
- Agri-environment payments
- Organic farming
- Non-productive investments
- First afforestation of agricultural land

http://enrd.ec.europa.eu/enrd-static/fms/pdf/20C9D871-BC5A-C82D-C407-44FDCA7854EE.pdf, last access 3/31/2016,1:36 PM)

5.7.2 Nitrate directive

Some areas of Castilla-La Mancha are designated NVZs (see Figure 22). In the NVZs, the amount of applied nitrogen is restricted and rules for application (also fertigation) are defined (ASAJA 2007).

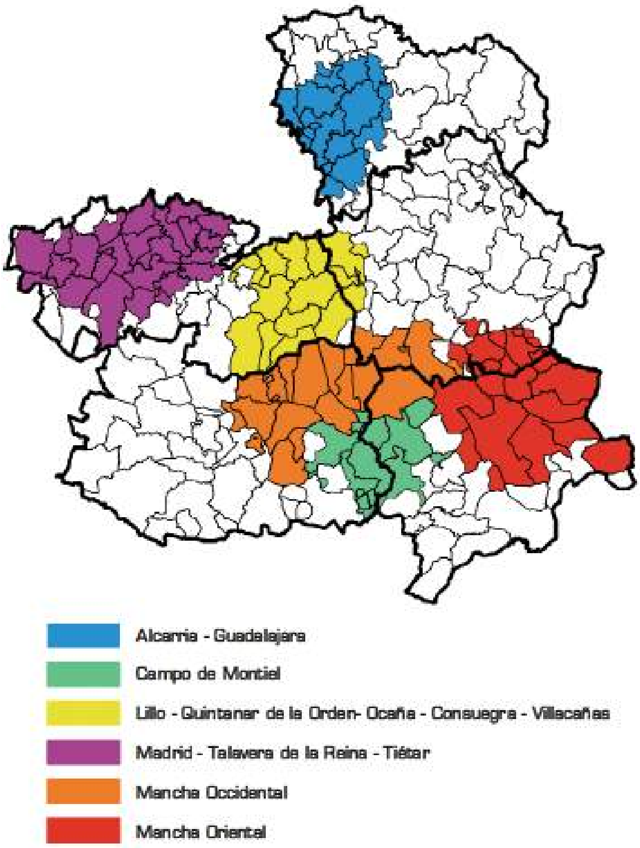

Figure 22: NVZs in Castilla-La Mancha (Source: ASAJA 2007)

5.8 User requirements

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2.

During the 1st Plenary Meeting from 7-9th October in Albacete (Spain) a roundtable of Spanish stakeholder took place. The following participants presented the needs of their institution or of the stakeholder group:

- Joaquín Rodriguez, employee of the Ministry of Agriculture and Environment, now is managing Director of SEIASA (state society of agriculture infrastructure) represented the national view
- ITAP (Instituto Técnico Agronómico Provincial de Albacete) represented by the technical director Ramón López, highlighted regional problems
- Vicente Bodas, farm consultant in the region around Albacete
- Agustín González and represented the average farmer of the area. Agustín González has a farm with 150ha. He is using a conservation technique with no tillage. His main crops are wheat, barley and maize
- Julián Illán is working at the large farm La Dehesa de Los Llanos which is a farm of 10.000ha. The farm is organized as agricultural company producing besides commodities (wheat, barley, maize…) some final products such as wine, cheese, oil, nuts, or lavender.

Joaquín Rodriguez outlined that it is important to improve the experiences and learn from mistakes from the past. The quality of life of the farmers related to various aspects shall be enhanced by higher incomes with higher quality of products and a more sustainable use of resources. He also pointed out that farmers have a certain obligation to the society as they receive funds from the state and are therefore obliged to use them in reasonable way. He highlighted that the importance of technology transfer to users of the advisory services as developed in FATIMA and that the ministry is willing to support these actions in the future.

Ramón López expects from FATIMA an operational tool to transfer information to the farmers with recommendations for irrigation and fertilizer application. He hopes that a large area will be covered by the FATIMA tools to improve the use of water resources and to avoid further contamination of water. He thinks that in the future a high quality of products is necessary to be competitive

Vicente Bodas shares the opinion of Ramon Lopez and adds that is important to give the farmers fast and accurate information as their crops develop, so satellite imagery plays a crucial role.

Agustín González predicts a negative scenario if the current soil management practices are not changed: an alkaline soil with weak texture, a low level of organic matter and other nutrients and often only 30 cm depth requires “conservation tillage” practices.

Both fertilizer and water represent expensive input costs for production and should be optimized or reduced to increase the income of the farmers and face the challenges of the climate change.

He thinks that rainfed crops will not be viable anymore in the future. The farmers must search for a better way to manage the scarce recourses. They are at the mercy of the prices decided in Chicago, so they have no power to influence them. Many farmers are old and there is no perspective for young farmers for the future. Taking all these facts into account, improved soil management with the tools of FATIMA becomes even more important.

Julián Illán highlighted the importance of efficient water use. This topic was ignored in the past, but receives higher recognition now due to the current economic situation with low prices of cereals. Therefore, technical recommendations are fundamental to make the farm profitable and respect the environment.

According to his opinion, a more precise use of input resources is required. His farm follows the recommendations of ITAP, but many farmers are ignorant with respect to these recommendations. The improved guidelines, which will be produced during FATIMA, will be useful to provide higher incomes for farmers. He expects personalized recommendation for single parcels for every week. At his farm, they changed their habits 10 years ago with the help of the consultant Vicente Bodas and the results were positive, so they want to do this more precise.

He expects farming in Albacete is going to change to woody and horticultural crops. He is hoping for an association of products from Albacete with high quality like it happens now with onions from Valencia.

5.9 Campaign plan

5.9.1 General purpose of the campaign

The pilot site in Spain ranks among the advanced sites where SPIDER tools have been used for about 10 years in previous projects (Pleiades, SIRIUS). Therefore, end users are very well prepared to use the FATIMA tools. The main purpose is to provide users (farmers) with FATIMA products (maps of nutrient & water requirements and yield) in near-real time (few days in advance they need to apply in the field). This includes predictions for one week ahead (water), nitrogen requirements as crops develop for dress applications, and other nutrients seasonal balance

In 2015 the 1st pilot campaign at the pilot site was organized with the main aim to test-deploy a first version of FATIMA products/services and evaluate with users in order to fine-tune and get ready for the 2016 main pilot campaign and to obtain a first dataset

5.9.2 Field trials in 2015

5.9.2.1 Purpose

The purpose of the field trials is to establish a ground truth for calibration and evaluation of EO products (maps of water, nutrients and yield).

5.9.2.2 Design

The trials encompass the testing of different N-application rates for winter wheat (7 plots) and maize (3 plots). Sampling of different parameters was done based on crop development and soil variability. For details see D3.3.1.

The range of spatial variability and N-input sensitivity was tested with stripes of 3 different inputs: N, N-x and N+x. The testing took place in almost 300 ha of 10 commercial plots, in every of them 9 intensive monitoring micro-plots were established (but the total surface of the plots were monitored and harvested together).

The criteria for the selection of plots were:

- mostly irrigated, but also some rainfed.
- if possible include conservation agriculture or organic.
- access & monitoring protocol feasible (in particular for intensive plots);
- farmer committed to collaborate (the size of the plots requires commercial equipment)

5.9.2.3 Results

After a previous characterization of the soil by its potential productivity in three main categories (low, medium and high), the response of every category to three different nitrogen rates have been study in order to make a spatial nitrogen balance to fine-tuning next seasons fertilizer recommendations. An example of a field trial is shown in Figure 23.

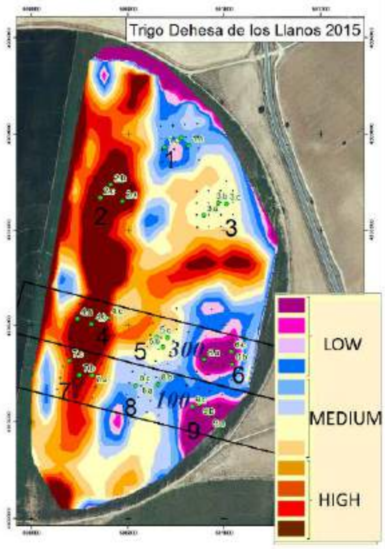

Figure 23: Example of field trial with classification into three potential productivity classes

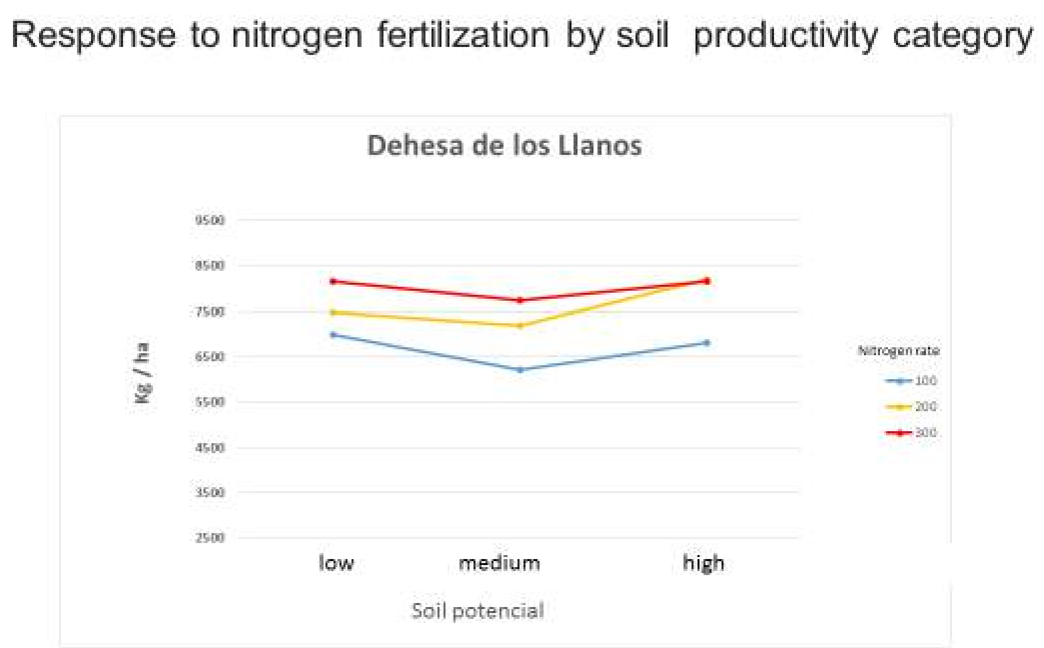

Figure 24: Previous soil productivity classification made by biomass model and remote sensing images, trial layout with different nitrogen rates and final yield response by soil productivity class.

5.9.3 Description and purpose of Earth Observation

5.9.3.1 Purpose

The purpose of the campaign is

- to obtain maps of nutrient & water requirements every 1-2 weeks (Landsat-8)
- to obtain maps of yield (prediction & end of season);
- to produce maps of nutrient & water requirements at higher spatial resolution (Sentinel-2 as soon as available 10m, RapidEye 5m, WV-2 2m) at selected dates of strategic importance in crop phenology;
- To analyse sensitivity of maps to different image resolution.

5.9.3.2 Design

The experiment and demonstration will require a basic set of 12-15 high spatial resolution satellite images over the crop growing season (about 6 months: April-September). Bi-weekly images (every 14 days) will needed during rapid growth phases, while for the rest of the time monthly images are sufficient. Consequently, the basic EO data requirements for the campaign can be summarized in a revisit time of 14 days and a spatial resolution of 10-30 m pixel size. Satellite images acquired in the visible, near and short-wave infrared will be used. Various satellite data providers satisfy our requirements (e.g. Landsat-8, SPOT, Pleiades, Sentinel-2 and WorldView-2). The choice of the EO data will be based on a trade-off between EO data availability and cost, and ability to describe crop growth cycles with adequate spatial resolution.

5.9.3.3 Results

Time and spatial crop development monitoring in a real time, with almost an image per week processing. For Landsat 8 processing in less than 48 hours after satellite taken.

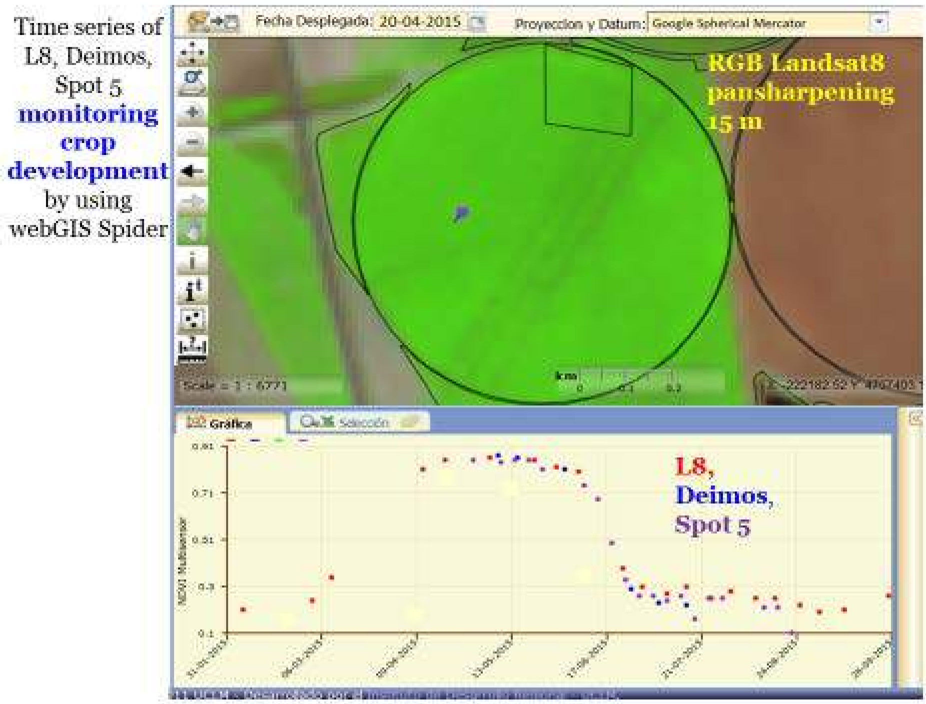

Figure 25: Spatial crop water requirement calculated a week ahead.

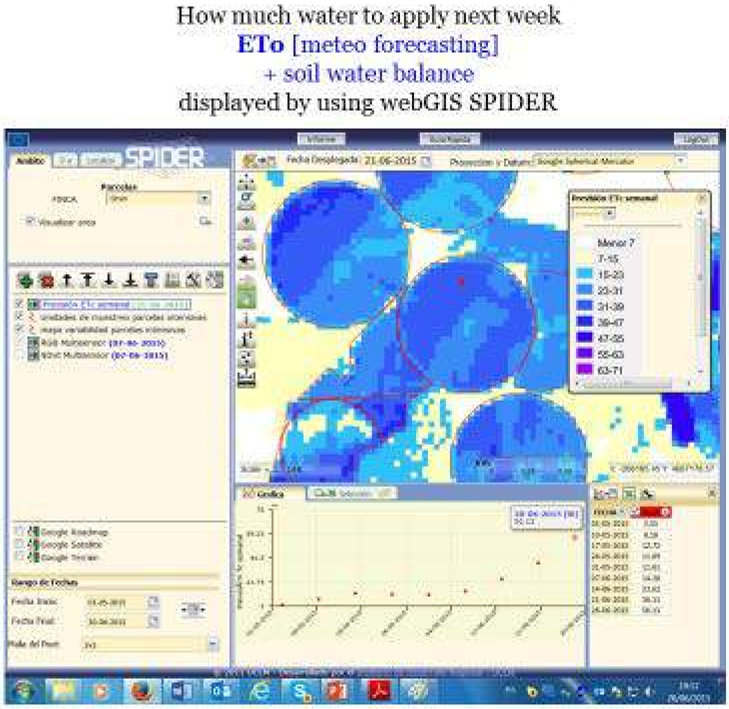

Figure 26: Validation of remote sensing biomass model with ground thruth from combine harvester yield monitor.

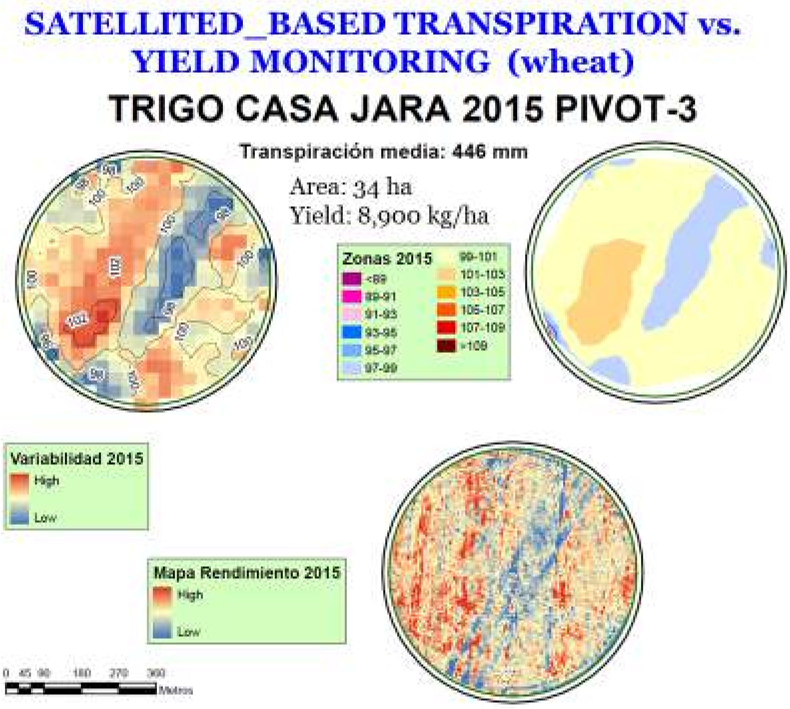

Figure 27: Wheat trials summary of validation procedure.

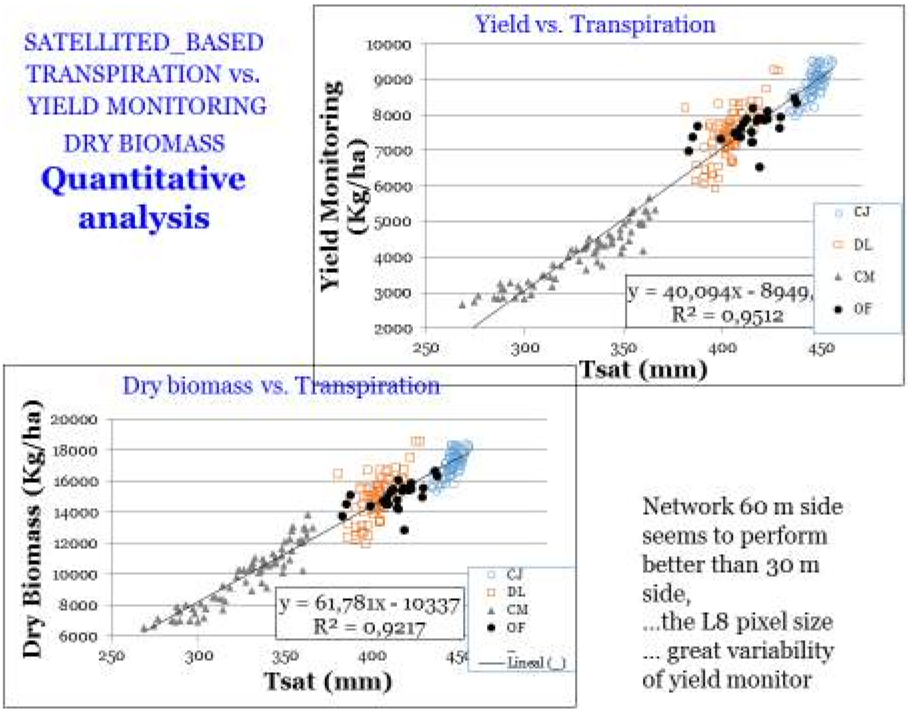

Figure 28: Quantitative analysis of correlation between biomass/yield and transpiration

5.10 Pictures

Figure 29: Wheat in a center pivot

Figure 30: Maize at V8 stage in no tillage.

Figure 31: Maize in typical shallow soil.

Figure 32: Urea application in maize..

Figure 33: Soil sampling in maize.

Figure 23: Biomass sampling in wheat.

Figure 34: Radiometer calibration.

Figure 25: Taking radiometer measurement..

Figure 26: Checking combine yield monitor.

Figure 27: Harvest time with farm staff.

Figure 35: Wheat harvest.

Figure 29: Maize harvest.

5.11 References

ASAJA (2007) Programa de Actuación, applicable a las zonas vulnerables a la contaminación por nitratos de origen agrario en la Comunidad Autónoma de Castilla-La Mancha

Pedrero, F., Kalavrouziotis, I., Alarcón, J. J., Koukoulakis, P., & Asano, T. (2010). Use of treated municipal wastewater in irrigated agriculture—review of some practices in Spain and Greece. *Agricultural Water Management*, *97*(9), 1233-1241.

6 Avignon (France FR)

Avignon area is located in Provence region in the lower Durance Valley. The climate is Mediterranean with a strong water deficit during the summer. Irrigation is developed and takes profit of two sources of water: the aquifer and the Durance river. The aquifer recharge strongly depends on the Durance water supply thanks to natural flows through the river bed or the excess of irrigation where flooding techniques are maintained.

The main challenge addressed in FATIMA is to improve fertilization and irrigation by increasing water and nutrient use efficiency and reducing nitrate lixiviation. Better irrigation and nutrient practices are necessary to improve farming system profitability, overcome tensions on resources and preserve the environmental quality as water quality in aquifers. Another issue is the economic viability of irrigation channel networks. As a matter of fact, the irrigated surface from the channel tends to decrease, due to land use change and alternate sources of water.

6.1 Overview

6.1.1 Geography

The French pilot area is located near Avignon in the region Provence-Alpes-Côte d'Azur (43°55’/4°53’). It has a total size of 31.684 ha, of which around 50% are used for agricultural activities. Saint-Remy, Tarascon and Chateaurenard are the major settlements with in total around 57.000 inhabitants in the area.

The agriculture of the area is very diverse with a range of irrigated and rainfed productions. For irrigated production, the area takes profit of the Durance river source of water, which is strongly regulated through a network of channels and dams designed to secure water supply.

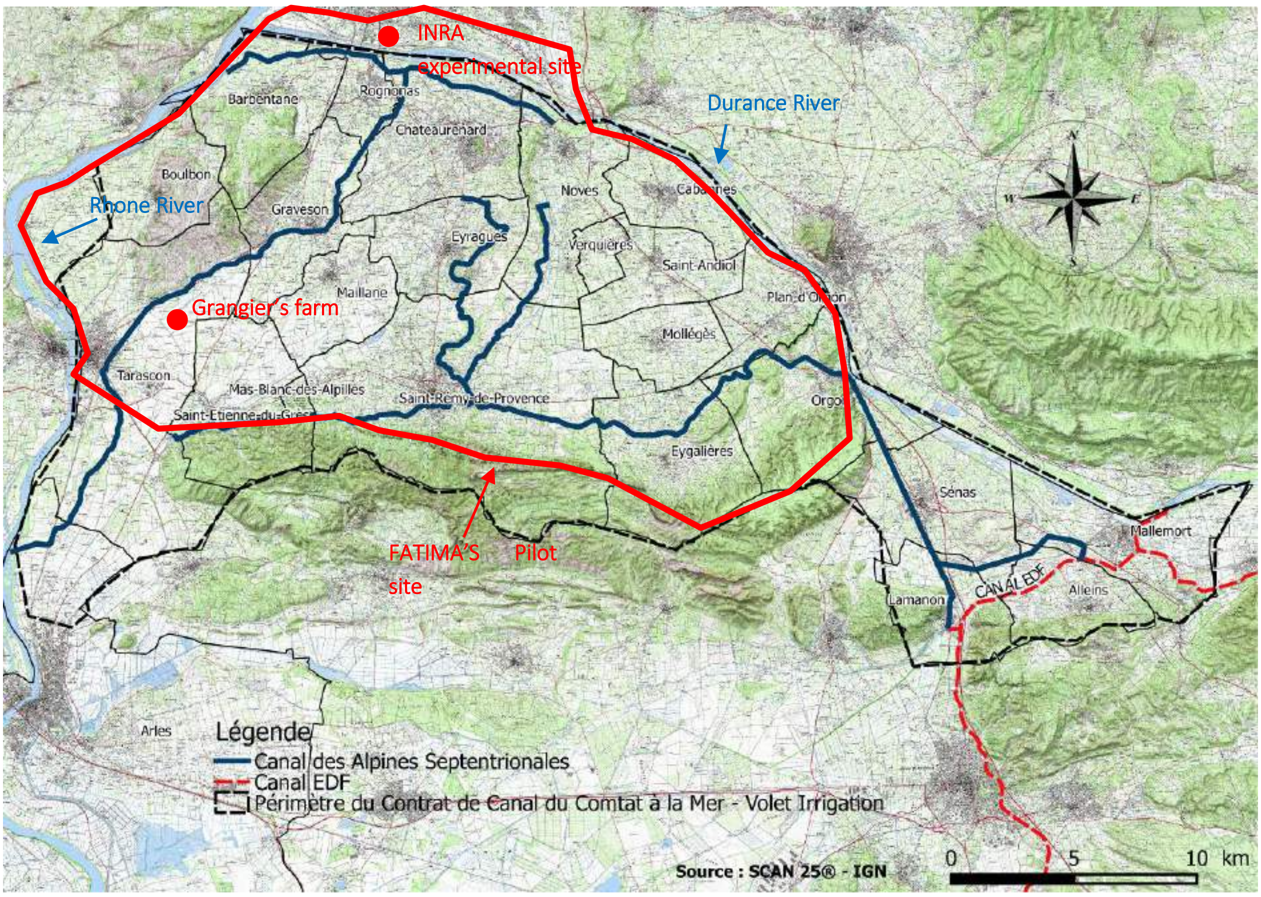

Figure 36: Map of the pilot area FR (adapted from J Harris, 2015)

6.1.2 Farm structure

The average farm size is 17.3 ha, but there are also larger farms in the area as e.g. the one of the "local champion" Jerome Grangier, which has a size of 300 ha.

6.1.3 Groundwater and soil

The soils are mainly developed on colluviums and alluviums (see soil map). In the lower part, soils are either hydromorphic or calcimagnesic, whereas they are calcimagnesic with stones or developed on limestones on the upper parts. Part of the hydromorphic soils were drained or used for rice production. A shallow aquifer (>20m) is mainly divided into two part separated by a central hill. In the western part a general flow links the Durance River to the Rhone.

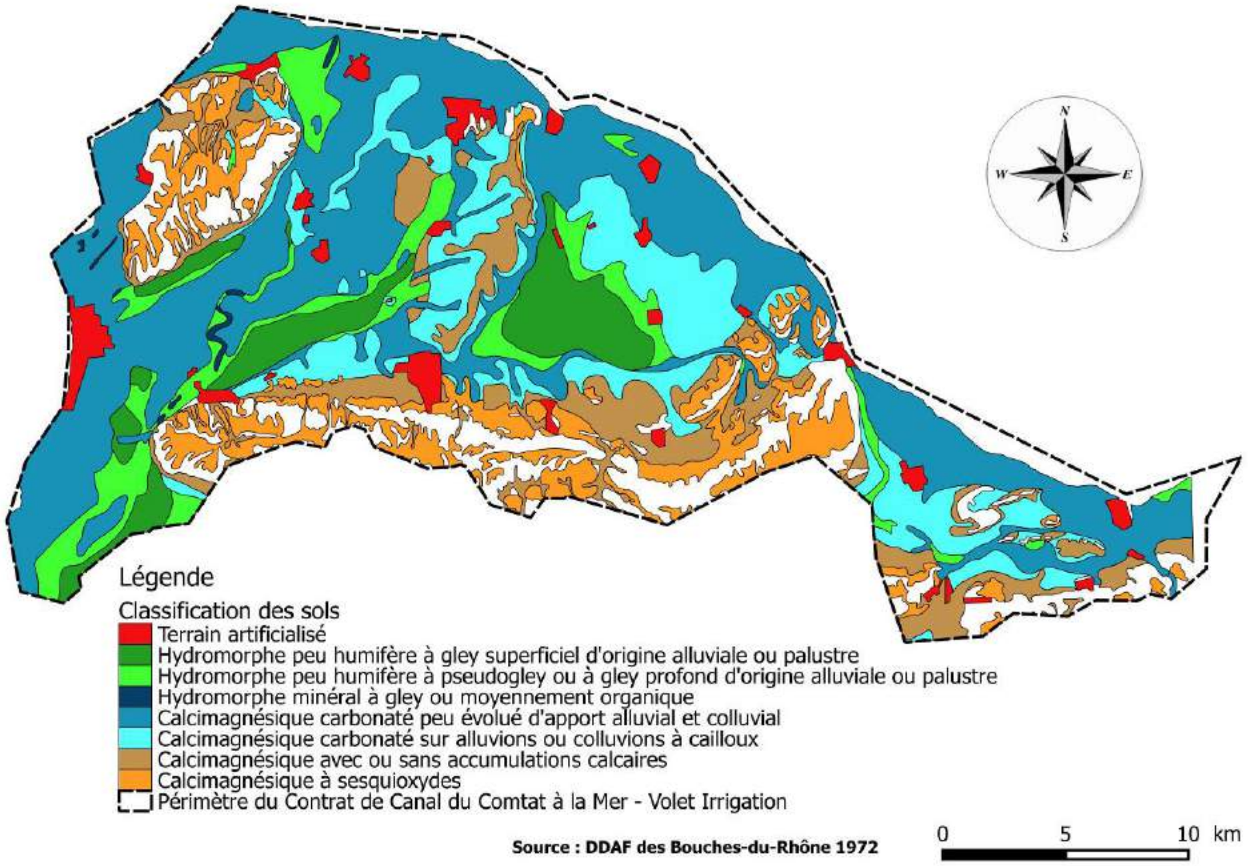

Figure 37: Soil Map (1/100000) of the pilot area (J. Harris, 2015, SICAS, Société du Canal de Provence)

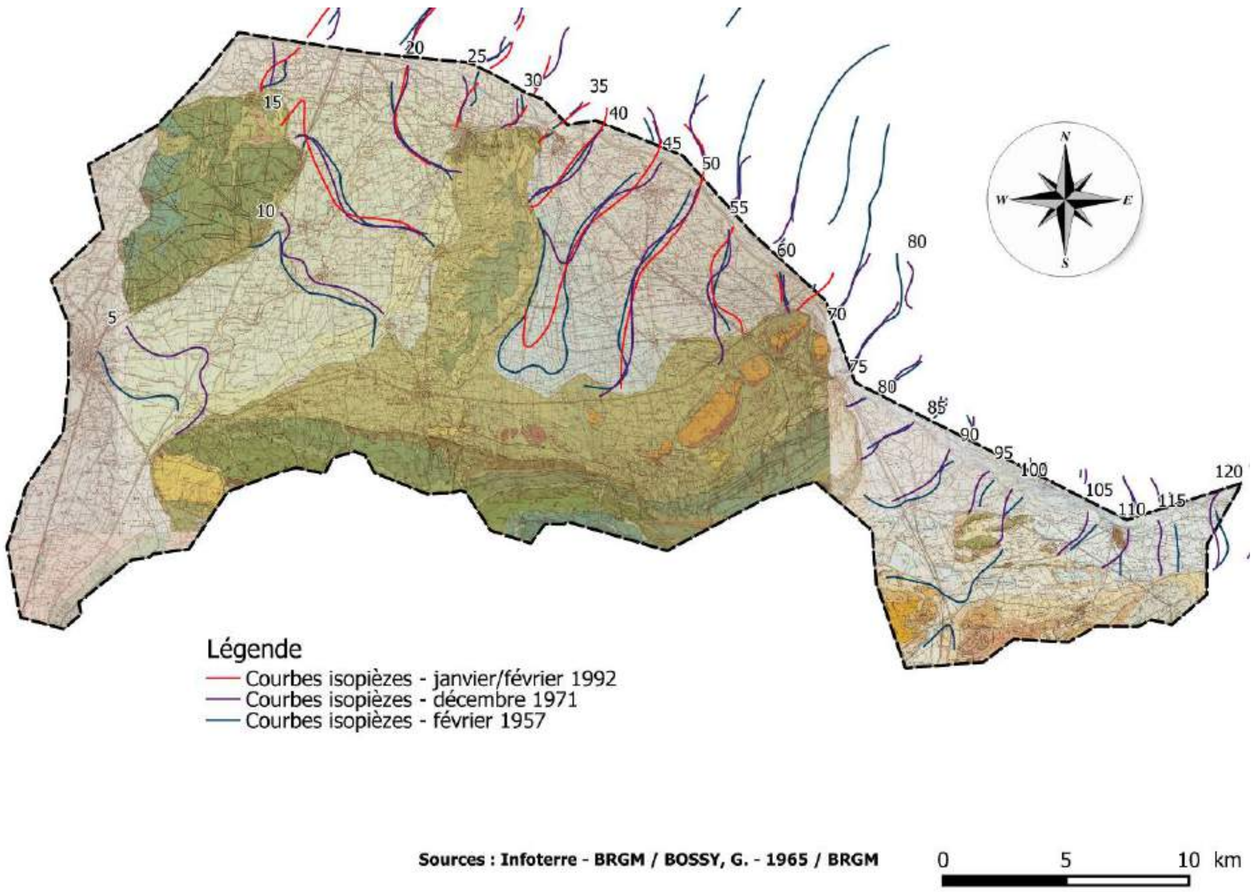

Figure 38: Piezometric map (from J. Harris 2015, SICAS)

6.1.4 Climate

Mediterranean climate is prevailing with annual precipitation of around 700 mm and evapotranspiration of 1150 mm.

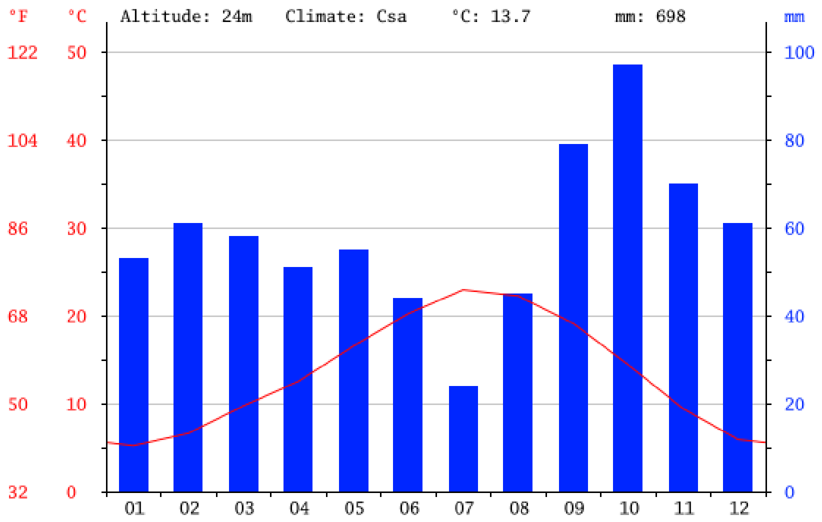

Figure 39: Climate chart of Avignon (Source: http://de.climate-data.org/location/717815/, last access: 3/31/2016, 1:36 PM)

6.2 Main challenges

In FATIMA the main issue is the improvement of irrigation and nitrogen fertilization at the farm level. A pilot farm is involved in the project, which is already equipped for precision farming. Two objectives will be addressed in FATIMA:

- Optimizing 2nd and 3rd Nitrogen fertilization by implementing VRT approaches on the durum wheat. The spatial patterns will be documented by potential yield (based on yield map), vegetation development given by satellite imagery and crop models.
- Improve the fertigation scheduling (tests on tomatoes) thanks to an evaluation of the water and nitrogen needs based on vegetation development, weather forecast and crop models.

At the territory level, channel contracts are under elaboration. The goal is to establish an agreement between all beneficiaries of the irrigation channels to organize the water distribution and cover the infrastructure cost. One of the problems is the competition between the two sources of water (surface, pumping). Since no charge is applied to pumping, there is a decrease of the irrigated surface linked to the channel and its economic viability may be questioned. FATIMA will bring tools to address socio-economic issues as well as technical tools to evaluate externalities to better identify all beneficiaries and thus share the cost.

6.3 Major crops

The major crops of the pilot sites are Field crop (35 %, including market gardening), fruit Orchards (14%), vineyards (4%) and grassland (2%).

Table 13: Major crop types in the pilot area FR (Data from the farm of Jerome Grangier)

	Crop	Total area (ha) within Pilot Area	Month of sowing / harvest (months of irrigation if applicable)	Average yield
Largest area	Wheat	200	November/June	6t/ha
2nd largest	Sunflower	60	April/September	2t/ha
3rd largest	Tomato	50	May/August	99 t/ha
4th largest	Sweet potato	30	May/September	40t/ha

6.4 Current practices related to water and fertilizer use

Table 14: Average fertilizer and irrigation amounts in FR

Crop	Average nitrogen amounts, estimation [kg/ha]	Average irrigation amounts per cropping season [m³/ha]
Wheat	180	0
Sunflower	0	0
Tomato	NA	NA
Sweet Potato	NA	NA

6.5 Water supply and wastewater treatment

There is a rain deficit in the area and, therefore, runoff water from the Alps is stored in dams and distributed over the Provence through the "Canal de Provence" infrastructure and hydraulic installations along the Durance River. The pilot site takes profit of this since the "Canal des Alpines", which distribute the water for irrigation purpose is plugged to this infrastructure. The other source of water is the superficial aquifer which is partly sustained by water from the Durance River (lateral flow from the river bed, irrigation using flooding techniques). Up to now, the aquifer level is not significantly affected by global change pressures and thus there is no need to have additional source of water (e.g. from waste water treatment). However, during the last decade, some restrictions were applied to the use of the surface water.

6.6 Irrigation infrastructure

The main infrastructure is the irrigation channel network of the "Alpines septentrionales". It consists of a network of a main channel and secondary channels to bring the water to the fields. As the initial water distribution is based on gravity, a very dense channel network was built (see Figure). Water is distributed on demand and a fee is established based on the irrigated surface. Due to urbanization, the change in irrigation techniques (introduction of drip irrigation) and an increasing use of aquifer pumping, the surface irrigated by the channel tends to decrease and thus threatened its economic viability.

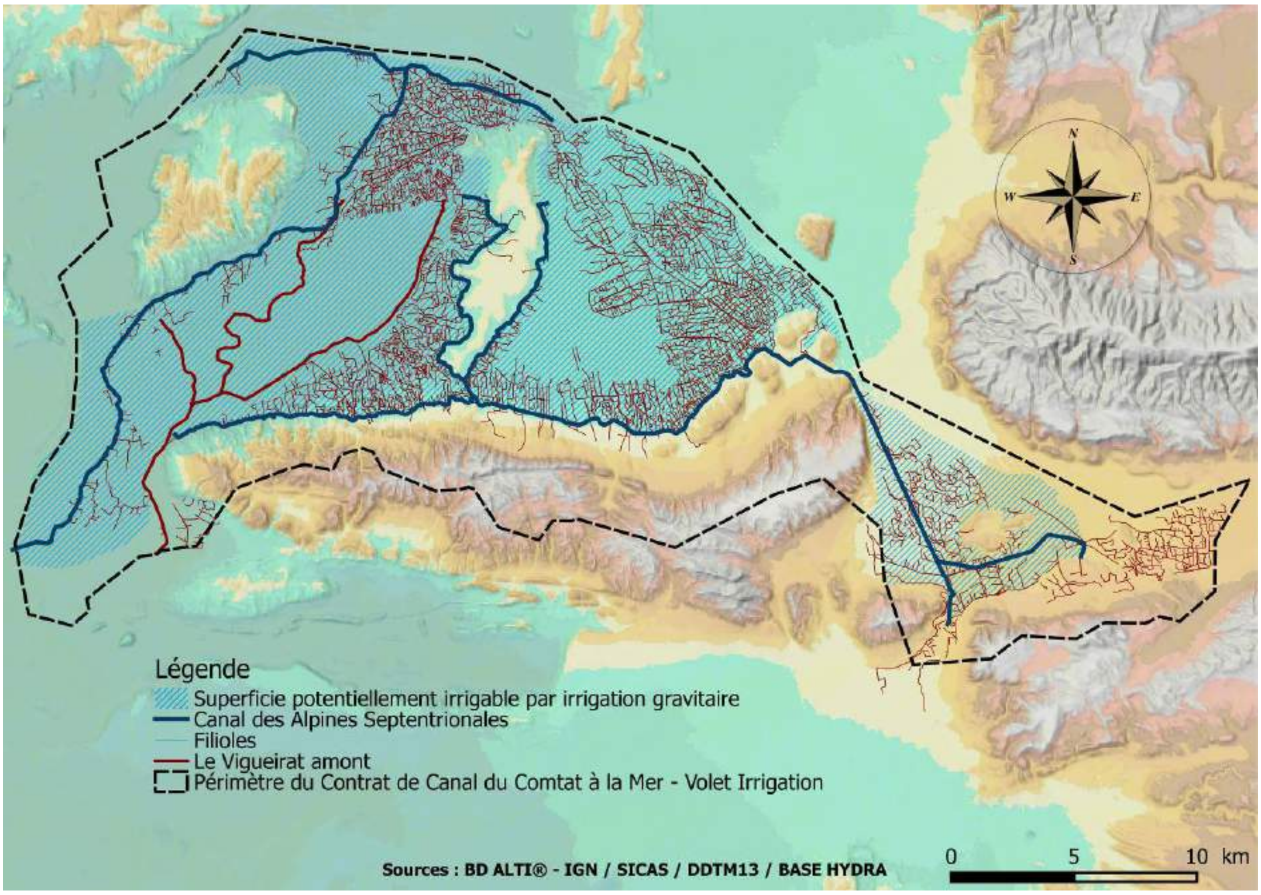

Figure 40: Channel network : main irrigation channels are in blue, secondary channel in brown (thin line) and sanitation channel in brown (thick line) (from SICAS, J.Harris, 2015)

6.7 Main policies relevant for rural development

The area is under the nitrate and water framework directives. Concerning the nitrate, low rates are observed due to the water renewal rate in aquifer leading to a nitrate dilution. Concerning the water framework, the trend is to increase the basal Durance river flow to maintain the ecological quality. This may reduce the availability of the irrigation water allocation. However, up to now such evolution did not impact the water availability.

Water tax system is under revision under the umbrella of the “Agence de l’eau”. It may lead to change in water source preference (aquifer vs surface water).

The southern part of the area belongs to the “regional park des Alpilles”. This can marginally have an impact on land use.

6.8 Key stakeholder and requirements (see D1.1)

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.

During the 1st Plenary Meeting from 7-9th October in Albacete (Spain) Jerome Grangier, a local farmer, participated and presented his requirements. He owns a farm with 300 ha and already applies various technologies related to precision farming on his field. He controls the spread of pesticides according to pictures made by drones and directs the tractor with support of a GPS system. He is very aware of the economic benefits related to precision farming technologies.

He expects from FATIMA to get for every field all information gathered in a single place to reach an integration of the results in one interface.

Other stakeholder are the SONITO (technical institute for tomato production) and SICAS which is the syndicate managing the irrigation channel. Other syndicates managing side areas (as Symcrau or "les arrosants de la CRAU") will be interested by FATIMA's Technical tools.

6.9 Campaign plan

6.9.1 General purpose of the campaign

The French pilot site will focus on field crops considering sunflower, wheat and field tomato, the latter being irrigated using fertigation technology.

The goals of experimental activities are :

- to test decisions support approaches based on comprehensive models (crop model, SVAT model) and assimilation of remote sensing and soil moisture observations and assess the adding value in comparison to more empirical approach as developed in FATIMA.
- to implement FATIMA's tools in real farm context and evaluate the benefit of such approaches. The experimental design will focus on the characterization of :
    - the nitrogen and water balance, the monitoring of the crop development and associated yields considering.
    - collect ancillary data for model implementation (soil characterization, climate data)
    - acquisition of high resolution images using drones in order to assess the field variability and address scaling issues.

6.9.2 Field trials

6.9.2.1 Purpose

The purpose of the field trials is to collect information on the nitrogen and water balance, crop development and yields.

6.9.2.2 Design

The experimental activities will take place at the INRA experimental site, which is located also in the pilot area, and at J. Grangier's farm where FATIMA's outcomes can be experimented in real farm conditions.

In addition, the INRA's experimental facilities located in north of France (MONS) will be included in the data and knowledge transfer. Even though it is not representative of the Provence agriculture, it offers a very interesting experimental set up combining different level of intensification and comparing conservation and conventional approaches. A long term experiment based on 7 treatments has been implemented with several replications, which are intensively monitored. This experimental framework will be used to test methods developed in FATIMA.

In 2015, the following activities took place:

- Avignon INRA : experimentation on sunflower with the full protocol to collect a reference set of data on sunflower.

- J. Grangier's farm : Acquisition of agronomic references on tomatoes to parameterize the STICS model (plant growth, nitrogen balance, transpiration, water leakage). Characterization of the field variability with drone campaigns. The aim was to prepare the campaign on tomatoes in 2016 and 2017.
- Mons INRA : collection of data in the core experiment. Measurements of the field variability with drones campaigns and measurements on vegetation.

In 2016, the following activities are foreseen

- Avignon INRA : experimentation on durum wheat with the full protocol to collect a reference set of data on wheat. Develop and test decision tools based on remote sensing and crop model. Compare those tools to more empirical approach developed in FATIMA.
- J. Grangier's farm : Provide fertigation recommendation for Tomatoes through the Spider platform and make a VRT experiment on Nitrogen fertilization on durum wheat using centralized information in Spider (the information should gather the meteorological data, spatialized development state from remote sensing, soil moisture measurements and crop model results).
- Mons INRA : collection of data in the core experiment. Measurements of the field variability with drones campaigns and measurements on vegetation.

6.9.2.3 Results

2015 was mainly dedicated to launch experiments and collect first sets of data. Two experiments were implemented, one at INRA on a Sunflower crop and another one on Tomatoes at Jerome Grangier's farm. Data collected consist in evaluating water and nitrogen balances and main soil characteristics as well as plant development and yields. Within field spatial variability was characterized at different scales using drones and satellite images. Strong spatial patterns were observed at INRA (see Figure 41), which make this site very interesting to develop decision tools in the frame of precision farming.

Figure 41: spatial variability of the sunflower at the flowering stage. Spatial patterns are strongly link to soil depth.

6.9.3 Description and purpose of EO

6.9.3.1 Purpose

In the French pilot site there are no experiences with Spider applications so far, but there are two systems that can be integrated into Spider. The objective is to centralize into Spider the EO information, meteorological data, soil moisture data, when available, and results of crop models. With this latter, EO data will be assimilated into the model to improve the prediction quality. To build irrigation and nitrogen fertilization recommendations, decision rules will be built using spatialized indicators derived from the crop model outputs and the observed data. Vegetation spatial variability revealed through remote sensing and yield map will be accounted for in crop models.

Spider, in its standard version, has been implemented this year for the season 2015. Uploading additional sources of information as spatialized indicator derived from crop models or soil moisture data will be implemented during the 2016 campaign.

6.10 Ongoing / past activities

The FATIMA will build up on earlier projects such as AGADAPT (https://www6.inra.fr/agadapt/), Astuce and Tic which supported the development a multi-simulation framework on the main field crops at the territory scale. On the INRA experimental site, the "Rue des sols" project has very close finalities to FATIMA with the use remote sensing series of data to retrieve the soil water storage capacity. The Mons Site is supported by the SOERE program (long term experiment in environment). Similar project were implemented in associated area ("plaine de la CRAU"). Stakeholder from that area will be invited to give their advices on Fatima's products.

6.11 Pictures

	
Figure 42: Tomatoes field within pilot site landscape	*Figure 43: Drone used to collect very high resolution images*

	
Figure 44: Flux tower on IINRA experimental sites	*Figure 45: Main irrigation Channel at St Remy*

6.12 References

Harris, J. (2015), Etude préliminaire à la construction d'un modèle hydrodynamique de nappe sur le territoire du Comtat et du nord des Alpilles, Master Report, Université D'avignon et des pays de Vaucluse, 32p)

7 Pinios River Basin Thessalia (Greece GR)

The Pinios River Basin is located in Thessalia in central Greece. It is considered to be the principal agricultural region of Greece, as its plain is the most intensely cultivated and productive agricultural area in the country. The economy of the Thessaly region depends mainly on agriculture as a high percentage of the population is partly or fully employed in agriculture.

The landscape is characterized by intensive agriculture with high irrigation and fertilization rates. During the growing season, irrigation water is limited and both fertilizer and water are applied uniformly independent of soil and crop conditions. Wheat and cotton are the major crops in the pilot area.

Soils are very heterogeneous and the application of the right amount of fertilizer and water is difficult for farmers. FATIMA aims at the development of a VRT applicator to facilitate the decision.

7.1 Overview

7.1.1 Geography

The Pinios River Basin and the drainage basin of the Former Lake Karla in Thessalia cover an area of 10.500 km² of which 450.000 ha are agricultural land (36%) and forests (19%). It is intensively cultivated, an activity which is accompanied by the use of large amounts of fertilizers. Around 55% of the agricultural land is irrigated. The capital city of the region is Larissa with 160.000 inhabitants. Other major cities are Trikala and Karditsa.

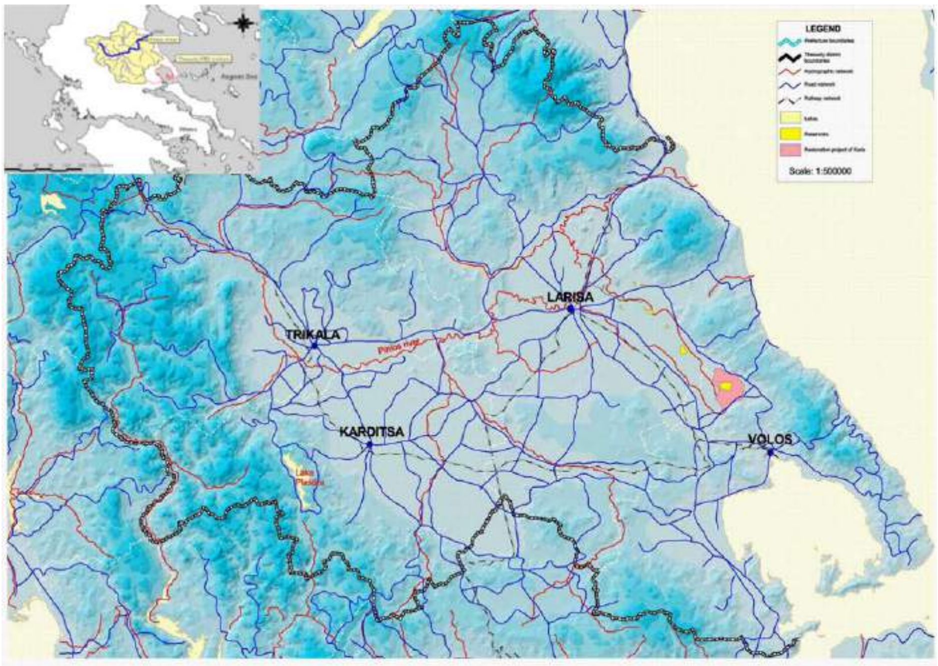

Figure 46: Map of the pilot area in Greece, Source: Ministry of the Environment Urban Planning and Public Works

7.1.2 Farm structure

The average size of a farm is around 5ha and single plots have a size of 1ha. Plots get smaller with every generation as they are divided between the heirs. An additional obstacle is the scattered location of the parcels, which requires long travel distances to check the crop status.

7.1.3 Groundwater and soil

The increased needs of irrigation water in Pinios river basin were fulfilled by the over-exploitation of groundwater resources. It is estimated that in 2004 nearly 65.000 ha were irrigated with surface waters and more than 210.000 ha with groundwater (Loukas and Vasiliadis, 2004). Groundwater overexploitation, especially during extended dry periods, had led to the deterioration of the already disturbed water balance and the degradation of water resources. From 1970 up to 1996 about 30.000 permissions for bore constructions were approved from which about 23.000 were executed (Goumas 2006). Moreover, an undefined number of illegal bores contribute in the over exploitation of ground waters. The amount of water pumped annually from the aquifers in the Thessaly plain is much more than the naturally recharged water within a hydrological year. The problem is more intense in the east Thessaly where the water table decline is continuous without any time of reset. The intensity of the water exploitation and the sharp decline of water table level without reset differ locally. In the area of Damasi - Tirnavos, the mean level decline for the period 1980-1998 was about 3-4m while the maximum water table decline is more than 11 m. The maximum water table decline was recorded in Pinias, Platykampos, and Rizomilos areas while in Tirnavos area the water table decline was less than the maximum.

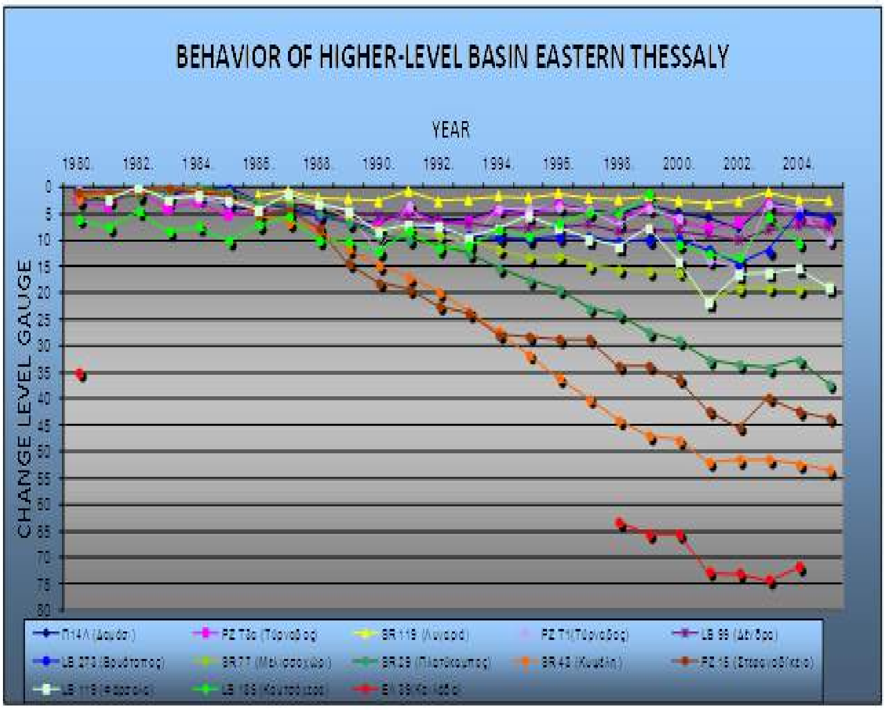

Figure 47: Illustration of the upper level of water table in the watershed of east Thessaly

In the Pinios basin area, the dominant soils belong to the following four categories: the recent alluvial soils classified as Entisols (Xerofluvents) i.e. soils formed on alluvial deposits located close to rivers streams, the slightly developed soils with cambic horizon classifieds as Incptisols (Xerochrepts), which are soils developed in some distances from the river basins, the soils with a well-developed argillic horizon classified as Alfisols (Xerlafs) formed in areas with higher elevations, and soils found in the lower parts of the floodplains with high clay content classified as Vetisols (Xererts). Entisols and Inceptisols are fertile soils on which most of the significant agricultural crops are grown. Alfisols are also important agricultural soils especially when they are treated with appropriate soil amendments to improve their acidity or other physical properties. Vertisols are heavy soils very fertile but needing special care for their cultivation management.

Agricultural practices are one of the main factors that drive soil degradation in the Pinios river basin. According to the Greek Action Plan to combat desertification, 30% of the territory faces severe problems of desertification. The land has been highly degraded mainly due to soil erosion and, under dry climatic conditions; vegetation growth and crop production have declined substantially in those areas. Cultivation of highly degraded land is not economically feasible, leading to land abandonment with adverse consequences for the local economy (Kosmas et al., 2006). In recent years, cotton monoculture, extended even to hillsides with ≥10% slope gradient. Cotton stalks are chopped and ploughed in after autumn harvesting, leaving the soil bare over winter. Large areas of land remain uncovered during winter and early spring, due to late crop establishment and growth. Irrigation with high-pressure guns also causes high soil erosion rates. Soil erosion caused by water can remove large amounts of N- and P-fertilizers, especially when applied to the soil surface. Traditionally, fertilization of cereals and fruits is achieved by spreading mixed fertilizers on the soil surface during the winter period. Under such conditions, large amounts of nutrients can be transported to surface waters by surface runoff, causing pollution problems and eutrophication of lakes and reservoirs. Tillage erosion is considered one of the most important processes of land degradation in hilly cultivated areas of Thessaly. Soil studies in hilly areas showed that soil depth has been reduced by 24–30 cm in the period from 1936 to 1999 (Kosmas et al., 2006). One other important soil degradation process affected by agriculture in Pinios river basin is the soil organic matter decrease. Analytical data on soil organic matter content of the topsoil of hilly lands in Thessaly have shown a reduction from 2.6 to 1.5% during the last six decades (Kosmas et al., 2006). This is mainly attributed to management practices (oxidation, burning of the remaining plant residues) and losses due to water erosion. The removal of organic matter reduces soil aggregate stability, adversely affecting soil erosion

7.1.4 Climate

The climate of the study area, is continental at the western and central side of Pinios river basin and Mediterranean at the eastern side. Winters are cold and wet and summers are hot and dry with large temperature variation between the two seasons. Mean annual precipitation over the Thessaly region is about 700 mm and it is distributed unevenly in space and time. The mean annual precipitation varies from about 400 mm at the central plain area to more than 1850 mm at the western mountainous areas. Generally, rainfall is rare from June to August. Mountainous areas receive significant amounts of snow during the winter months and transient snow packs are developed.

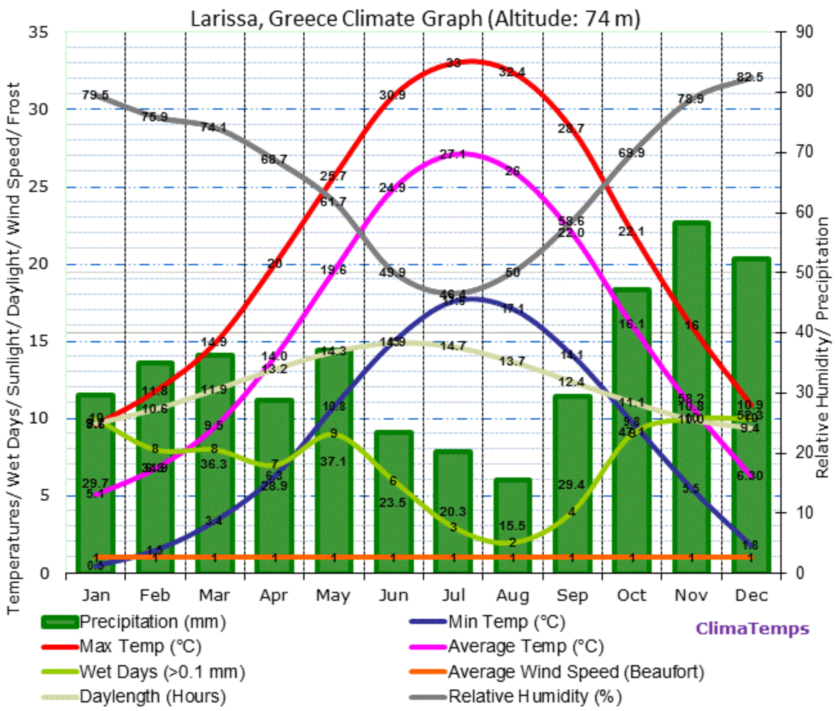

Figure 48: Climate chart of Larissa, Source: http://www.larissa.climatemps.com/, last access on 31.03.2016,1:36 PM

7.2 Main challenges

The main agricultural challenges in the pilot area are:

- Low soil organic matter content reduces soil fertility.
- High soil clay content influence crop yields.
- Fertilizers and pesticides are uniformly and excessively applied independent of soil spatial variability.
- Limited availability of irrigation water during the summer growing season leading to water over exploitation and illegal drillings.
- Small plots inhibit efficient cropping methods.

7.3 Major crops

Table 15: Major crop types in the pilot area GR

	Crop	Total area (ha) within Pilot Area	Month of sowing / harvest (months of irrigation if applicable)	Average yield (kg/ha)
Largest area	wheat	180.840	November/June (1 irrigation)	3.200
2nd largest	cotton	100.669	May/ September (3)	3.800
3rd largest	maize	20.000	April/ September (4)	13.000
4th largest	orchards	43.150		

7.4 Current practices related to water and fertilizer use

Around 90 % of the supplied water is used in agriculture mainly fed by groundwater from single wells.

Table 16: Average fertilizer application and irrigation volumes GR

Crop	Average irrigation volume (m^3/ha)	Average fertilizer application (kg N per ha; organic or mineral; solid or liquid)
wheat	750	160
cotton	6000	200
maize	8000	300

7.4.1 Legal Limits

The Action Plan for nitrate reduction in the Thessalia region sets limits for the nitrogen application according to crop and soil type and erosion risks. There are limits for irrigation rates in areas with declining groundwater level (http://www.jmecology.com/wp-content/uploads/2014/03/08karyotis.pdf, last access on 3/31/2016, 1:36 PM).

7.5 Water supply and wastewater treatment

Agriculture is by far the main water consumer representing the 90-95% of the annual water demand of the area, with irrigated land covering half of the total cultivated area. Cotton is the main crop cultivated in Pinios (~150.000 ha), with high water demands (600 mm water per growth cycle). Water is abstracted mostly from groundwater sources with few notable exceptions. Unfortunately, a significant percent of abstractions (more than 50%) is believed to be illegal and existing irrigation practices have low efficiency (incl. high runoff, canal conveyance losses due to seepage, leakage, evapotranspiration and sub-optimal management of the irrigation water). Water overexploitation leads to low river flow (negligible in the summer), the drying up of small lakes/reservoirs and low groundwater levels, which make water more expensive to obtain (deep pumping) and enhance saline water intrusion in coastal areas.

The Pinios river is the main river of the water region and its basin covers almost the entire region of Thessalia. It receives agricultural runoff from the intensively cultivated Thessalia Plain and treated wastewater of around 300.000PE and untreated wastewater from some smaller settlements. The construction of wastewater treatment plant (WWTP) led to an improved water quality in the last decades. (Argyropoulos, 1997). There are eight WWTP located in the pilot area. All WWTPs comply with the EU Directive 91/271 requirements as adopted by JMD 5673/400, 1997 setting the limits on the qualitative characteristics for the effluents of the municipal WWTPs in Greece. Table 17.

Table 17: Current treatment capacity of WWTPs in Pinios River Basin

	WWTP	P.E. (current)	Total Flow ($10^3 m^3$/year)
1	Larissa	135 000	9 800
2	Trikala	51 000	3 730
3	Karditsa	49 000	9 420[4]
4	Kalampaka	12 000	830
5	Elassona	5 800	410
6	Farsala	4 000	220
7	Tyrnavos	5 000	460
8	Giannouli	4 000	170

7.6 Irrigation infrastructure

The development of the agricultural sector in Thessaly, during the past 40 years is intimately linked with the implementation of a series of infrastructure projects, including the draining of lakes, land reclamation, flood protection and expansion of irrigation networks. The irrigation water is either managed by organized bodies (Local Organization for Land Reclamation-LOLR, communities and municipalities) or by individuals. The irrigation system in Pinios River Basin consists of 105 collective systems, 76 pumping stations, 15 reservoirs and 31.000 boreholes (Mahleras, et.al., 2007). Most of the canal-irrigated systems were constructed in the 60's and 70's and have significant maintenance problems affecting their regular operation and efficiency. The development of the surface piped systems can be traced back to the 80's (development of sprinkler irrigation), while in the last two decades some underground systems have been constructed. The collective networks are under the supervision and scientific support of the Land Reclamation Directions in the Prefectural Services of Thessaly. Three types of irrigation systems are used in the area: a) sprinkler irrigation (75%), b) drip irrigation (25%) mainly for cotton, and c) furrow irrigation (5%). Today drip irrigation in Thessaly, accounts for approximately 50% of the cotton cultivated areas. Nevertheless, because of the high installation costs and its relatively short life-span, it is currently being introduced primarily in areas that combine intense water shortage problems and lack of irrigation networks with high crop yielding capacity. Around 75.000 ha are irrigated by surface waters and 178.000 ha by groundwater of the Thessalia Plain. Groundwater is abstracted from a large number of boreholes (>30.000). High irrigation volumes are applied due to the salty soils in the area.

7.7 Main policies relevant for rural development

7.7.1 Nitrate directive

According to the requirements of the nitrate directive vulnerable zones have been identified in Greece an action program has been formulated. The Western and Eastern parts of the Pinios River Basin are vulnerable zones based on the fact that the area is intensively agriculturally used and nitrate levels of groundwater

[4] The flow of Karditsa WWTP is extremely high regarding the Population Equivalent. This is mainly because of high infiltration and illegal stormwater connections to the wastewater network.

measurements in Argyropoulio exceeded 50mg/l. (http://ec.europa.eu/environment/water/water-urbanwaste/pdf/greece.pdf, last access on 3/31/2016, 1:36 PM).

7.7.2 Water framework directive

The ecological status of natural surface water bodies presented in the RBMP of Thessalia shows that only 23% are in high or good status (7% and 16% respectively). Another 27% are in moderate status and even 40% are in poor and bad status which is the highest share in whole Greece.

The chemical status of groundwater bodies in the region reaches in 87,5% of the groundwater bodies good status whereas only 69% feature good quantitative status. (http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/MS%20annex%20-%20Greece.pdf, last access on 3/31/2016, 1:36 PM)

7.8 Key stakeholder and requirements (see D1.1)

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2.

During the 1st Plenary meeting in October 2015 in Albacete (Spain) the farmer Giorgos Samaras presented the requirements from the farmer's perspective. He owns a farm of 130ha, which is – compared to average Greek farmer – a very large size and sells agro-business products (fertilizer, seeds) as additional income. Giorgos Samaras highlighted various problems that farmers face in the pilot area: Small plots (<5ha) become even smaller with every new generation as parcels are divided. The soils are salty as the drainage system is not working well and farmers are forced to apply large volumes of irrigation water. After irrigation the soil gets very hard; therefore they have to irrigate very often small amounts.

In addition the high volatility of prices and the costs for complex fertilizers decrease the income of the farmers and they feel at the mercy of global markets. He bases the decision on fertilizer amounts on soil analysis, which are expensive. His goal for the future is to produce more with less input and more profitability.

To achieve this, he hopes that FATIMA will enable farmers to better apply fertilizer to their fields. He supports the development of the VRT applicator and hopes that this will facilitate the decisions how much fertilizer to apply in the future.

7.9 Campaign plan

7.9.1 General purpose of the campaign

The goal of the campaign is to implement real-time and variable-rate (VRT) application of granular fertilizers in order to reduce nitrogen (N) inputs, increase crop yields and improve environmental performance of cropping systems.

In a next step, these management practices will be presented to users (farmers) and the economic benefits for converting conventional N management to site-specific N management shall be demonstrated.

7.9.2 Field trials

7.9.2.1 Purpose

The purpose of the field trials is mainly to perform real-time and Variable Rate Technology (VRT) N application under real field conditions and compare the system performance with conventional N management in replicated field strips. Detailed field trials will be undertaken on three crops (winter wheat, corn and cotton) in the Pinios River Basin for two consecutive growing seasons. Within-season VRT N will be applied by the ground sensor VRT application system. In brief, the operation of the system consists on mobile multispectral sensors mounted on a tractor vehicle that scan canopy reflectance, and the data are transformed to Chlorophyll Index (CI) and fertilizer N requirement by an N-response function (Holland and Schepers 2010) in real time. A controller utilizes the N-requirements data and drives the operation of the air spreader that spatially varies the application of N fertilizer.

More specifically the main challenges of field experiments are

- To develop a capable ground sensor VRT application system that has the potential to accept satellite maps
- To implement ground VRT N management and compare to conventional uniform N management
- To interpret differences between management practices by using ground truth data including monitoring of soil moisture and water balance estimates and calculate ET and drainage from the soil-water balance equation, based on the soil water content as measured by the installed soil moisture sensors
- To synchronize satellite image acquisition with VRT application time frame
- To overlay and correlate ground measurements with satellite data including fertilizer N requirement
- To Supervise Classification of World View 2 satellite images and compare WV2 canopy indexes with free LANDSAT image data

7.9.2.2 Design

The experimental design of the commercial field trials is a randomized complete block design with 4 treatments and 4 replications under full scale field conditions by using field strips of 8 rows wide for cotton and corn and 5 m for wheat and 100 m long as experimental units.

The following criteria have been applied for the selection of the fields:

- Three of the major crops of pilot area (wheat, cotton, corn);
- Spatial variability in soil properties (ground sensor and satellite NIR maps) and past crop growth patterns (Google Earth images);
- Soil 15N signature ($^{\delta 15}$N>9 if possible)
- Field history without any records of organic manure application, unusual flooding and fire events;
- Access and monitoring protocol feasible;
- Farmer committed to collaborate (in trials & evaluation) with financial reimbursement;
- Farmer possesses suitable machinery and equipment (hydraulic tractor with tool bar to specifications, harvesters to support yield monitors).

The treatments will have the same irrigation, wheel traffic and plant protection management and are defined as follows:

Table 18: Treatment plan for field trials GR

Field	Treatment
Control	preplant PKN (40% preplant N)
farmer 1	preplant NPK (100% preplant N)

farmer 2	preplant NPK (40% preplant N and 60% in season uniform N application
VRT	preplant NPK (40% preplant N and 60% in season VRT N applications

Treatment rates of fertilizer-N (%) and their distribution within the growing season

Timing	Control application	Farmer single application	Farmer segmented application	Variable-rate application
	--------------------Uniform -----------------------			VRT
Preplant	40%	40%	40%	40%
Early-season	0%	60%	0%	0%
Mid-season	0%	0%	30%+30%	VRT
Total N applied	40%	100%	100%	40% + VRT

Figure 49: Schematic presentation of the experimental design in the field

Intensive monitoring takes place in the commercial field trials. The following parameters are monitored:

- Soil sampling & analysis (range of parameters determined by growth stage) (3 dates);
- Crop NPK, stable isotopes (2 dates);
- Yield spatial monitoring (end of growing season);
- Irrigation water & fertilizer applications;
- Canopy reflectance in 3 wavebands (red, red edge, NIR);

- Weather station (continuously/weekly).

The locations for the sampling are determined from the analysis of spatial heterogeneity with the goal to test 3-4 locations per field strip. The VRT N application (granular N) will take place in pre-defined strips.

7.9.2.3 Results

The ground sensor VRT application system was assembled but it is not yet fully operational due to communication problems of ground sensors data logger and air spreader applicator. Maps of N Application rates was created based on ground sensors data for cotton and corn, and an alternative method of variable rate N application was performed in cotton field. Yields of cotton and corn are expected in the next weeks (Nov 2015). Lab analysis of soil and plant samples is completed, and confirms spatial variability in soil and plant indexes in the field level.

In addition to VRT application very high spatial resolution imagery from WV-2 also applied to assist a possible estimation of seasonal nutrient, fertiliser and water needs of corn and cotton farms by cross correlating high spatial, spectral and temporal relationships of satellite data, acquired at well-defined time intervals of the phenological cycle of crops, with ground-truth information that is simultaneously applied, during the Earth Observation data acquisitions. More specifically, time-series satellite imagery with very high spatial and spectral resolution acquired during the growing season of two different fields (corn and cotton farms) processed for the purpose of generating diachronic maps of canopy reflectance and the Chlorophyll Index, evaluating the spatial fertilizer N requirement and comparing to that of the ground sensors at the time of in-season fertilizer application. Thematic maps and several vegetation indices were applied onto radiometrically and atmospherically corrected and georeferenced satellite imagery including FPAR, SAVI, LAI, Red-edge NDVI and CI2. Kc and ET satellite were also produced using Red-edge vegetation index.

For the Water balance evaluation during the entire growing season and soil moisture spatial distribution the soil moisture was monitored in 12 locations in the experimental fields of corn and cotton. Total amounts of irrigation and cumulative evapotranspiration was estimated. Deep percolation losses were calculated. From the spatial distribution of moisture we observed significant heterogeneity that appears to be due to poor drainage. Two Landsat-8 high resolutions satellite images were compared with WorldView-2 images in terms of Normalized Difference Vegetation Index, Leaf Area Index, Photosynthetically active radiation, and Crop coefficient (Kc)-based estimation of crop evapotranspiration. A supervised classification of the broader study area crops was carried out, utilizing a detailed field sample dataset and an analysis of the results in now in progress.

7.9.3 Description and purpose of EO

7.9.3.1 Purpose

The purpose of the EO campaign is to

- obtain high-resolution maps of canopy N requirement at a critical stage of the crop N uptake curve;
- implement real-time and VRT N application;
- synchronize satellite image acquisitions with VRT time frame
- overlay and correlate ground measurements with satellite date

7.10 Ongoing / past activities

There were a number of research activities focusing on the sustainable water/soil resource management in Pinios River Basin. Some of the most recent projects are presented below:

7.10.1 DG Environment, "I adapt"

The project "I-adapt" was a fully integrated investigation of solutions, including both demand and supply management measures as well as up scaling of results of field experiments through modelling. Specific field studies have been undertaken to investigate problems and solutions on the ground, for the case of Pinios and the results were up-scaled at the catchment level, through modelling. The project focused and tested several interventions, including precision agriculture techniques to reduce water loss on the farm and conveyance system losses to reduce abstraction. The reclaiming of treated wastewater as well as rainwater harvesting were also investigated as alternative water sources.

7.10.2 LIFE+ Environment: Innovative precision technologies for optimised irrigation and integrated crop management in a water-limited agrosystem (HydroSense).

The HydroSense project aims at the improvement of the water, fertilizer and pesticide use efficiency of a major Mediterranean agricultural crop (cotton) by employing principles of site-specific management and advanced technologies in proximal remote sensing. At the experimental sites, the principles of precision agriculture were applied through variable rate inputs governed by the efficient monitoring of crop needs in space and time. The preliminary results of the experiments indicate a reduction of water consumption up to 20 % in comparison to conventional management with uniform irrigation, a reduction in nitrogen fertilization by 20% and up to 50% reduction in pesticide and herbicide inputs.

7.10.3 FP6 : Participatory multi-Level EO-assisted tools for Irrigation water management and Agriculture Decision-Support (PLEIADeS).

The coordinator of the 3-year project (2006-2009) was the Universty of Castilla –La Mancha (Spain), while NAGREF /Institute of Soil Mapping and Classification coordinated the experimental sites in Pinios river basin. The Pleiades project aimed at the improvement of the performance of irrigation schemes by means of a range of measures that consider the economic, environmental, technical, social, and political dimensions through a synergy of leading-edge technologies and participatory approaches. The technical innovation used is based on the complementary use of mature Earth observation (EO) methodology in GIS-based web services with online analysis capability. These technologies provide easy access to information for all stakeholders while transparency and active participation are being enhanced by spatial information and innovative networking tools. The System for Participatory Information, Decision support, and Expert knowledge for irrigation and River basin water management (SPIDER) is the central technical outcome of the project. Its technical core consists of an advanced web-based GIS tool and a novel package of operational EO methodology. The design of SPIDER was oriented towards its global application, including the capability to be configured and installed by the responsible partner in each pilot area. In Greece, Pinios river basin was selected as the pilot case study and Pleiades could provide in the Pinios river basin information expertise, suggestions in regards to feasible assessments of crop water demand especially when regular in-situ measurements are available, but the effectiveness of these actions relies on the active participation and constructive cooperation between farmers and local actors.

7.11 Pictures

Figure 50. The ground sensor VRT system used in the field trials

Figure 51. Soil moisture data logger in the corn field

Figure 52. Scanning the cotton canopy with ground sensors to determine N rate applications

Figure 53.Visit in the experiments on the Greek regional meeting

7.12 References

Argyropoulos, D. (1997) Report on the Quality of the Inland Surface Waters of the Country", YPEHODE, Athens, July 1997

Goumas, K. (2006). The irrigation in the plain of Thessaly: Consequences in ground water and surface waters, Greek, Hydrotechnical Union Meeting February 2, 2006, Water Resources and Agriculture.

Holland KH and Schepers JS. (2010). Derivation of a variable rate N model for in-season fertilization of corn. Agronomy Journal 102:1415-1424

Kosmas, K., Danalatos, N., Kosma, D. and P. Kosmopoulou (2006). Soil Erosion in Europe, Edited by J. Boardman and J. Poesen. John Wiley & Sons, Ltd.

Loukas, A. and L. Vasiliades (2004).Probabilistic analysis of drought spatiotemporal characteristics in Thessaly region, Greece, Natural Hazards and Earth System Sciences (2004) 4: 719–731.

Mahleras, A., Kontogianni, A. and M. Skourtos (2007). PINIOS RIVER BASIN - GREECE (Deliverable D34), Aqua Money, Project report, pp. 27. (http://www.aquamoney.org/sites/download/piniosgr.pdf)

8 Piana di Tarquinia (Italy IT)

The area Piana di Tarquinia, is located in Center Italy, Lazio Region, with Important archaeological sites and historical assets of Etruscan-Roman era known nationally and internationally. There are problems due to groundwater pollution, and water management both in terms of quality and quantity. The area has been identified as nitrate vulnerable zone (EU Nitrates).

FATIMA will tackle these problems by providing fertilizer and water recommendation to farmers and institutional stakeholders.

8.1 Overview

8.1.1 Geography

The pilot area Piana di Tarquinia is located around 90 km north of Rome in the region Lazio. It has a flat topography, is an intensively used agricultural area and 85% of the area have been designated as nitrate vulnerable zone. The area has a size of 27.000 ha, of which 67% are agriculturally used. Around 45% of the agricultural land is irrigable and in 2014 actually 2.195 ha were irrigated. The major settlements in the area are Tarquinia, Lido di Tarquinia, Voltone and Marina Velca.

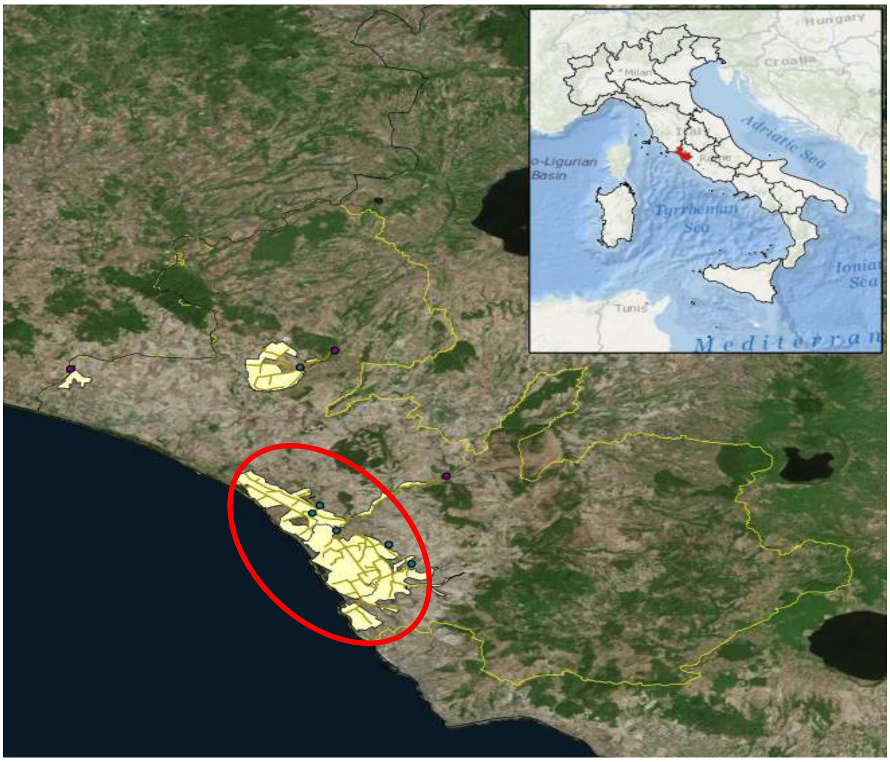

Figure 54: Map of the pilot area in Italy

8.1.2 Farm structure

The average farm size is 16 ha and single parcels have a size of around 2ha. There are 20% of small parcels with a size of less than 1ha.

8.1.3 Climate

The pilot area features a dry-sub humid climate with annual precipitation of around 670 mm, which mainly occur during the winter months.

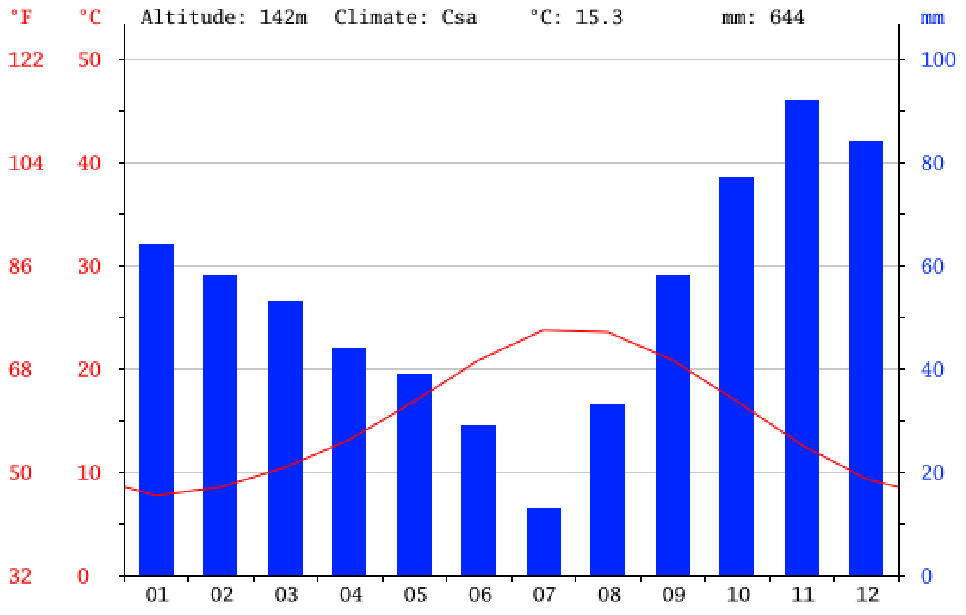

Figure 55: Climate chart of Tarquinia, Source: http://de.climate-data.org/location/14488/, last access on 3/31/2016, 1:36 PM

8.2 Main challenges

- Excessive use of fertilizer resulting in soil and in groundwater aquifer.
- Land and soil degradation.
- High energy costs for water pumping in irrigation networks.

8.3 Major crops

Table 19: Major crop types in IT

	crop	total area (ha) within Pilot Area	month of sowing / harvest (months of irrigation if applicable)	average yield (kg/ha)
Largest area	Durum Wheat	7,800	November-June	4,600 - 5,600
2nd largest	Industrial tomatoes	960	May-August	45,000 – 50,000
3rd largest	Watermelon	333	May-August	TBC

4th largest	Melon	272	May-August	TBC
5th largest	Fennel	144	August- January	TBC

8.4 Current practices related to water and fertilizer use

Table 20: Average irrigation amounts and fertilizer application

crop	average irrigation volume (m3/ha)	average fertilizer application (kg N per ha; organic or mineral; solid or liquid)
Durum Wheat	Rainfed	18,000-22,000 (mineral, solid)
Industrial tomatoes	3,200	15,000-20,000 (mineral, solid)
Watermelon	2,500	TBC
Melon	2,780	TBC
Fennel	940	TBC

8.5 Water supply and wastewater treatment

Surface water from rivers (Marta, Mignone) is the main water source for both domestic (47% of total water consumption) and irrigation purposes (53%).

8.6 Irrigation infrastructure

The majority of the irrigation systems is using drip irrigation (63%); the remaining ones use sprinkler systems.

8.7 Main policies relevant for rural development

8.7.1 Regional Rural Development Plan

The rural development program for Lazio (2014-20) defines goals that shall be reached within the program duration (http://www.lazioeuropa.it/files/140723/regione_lazio_psr_feasr_2014_2020_luglio_2014.pdf, last access 3/31/2016, 1:36 PM)

In line with Europe 2020 and the overall CAP objectives three long-term strategic objectives for EU rural development policy in the 2014-2020 period can be identified:

- fostering the competitiveness of agriculture;
- ensuring the sustainable management of natural resources, and climate action;
- achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

8.7.2 Nitrate directive

The Nitrates Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices.

In Italy, a national regulation empowers the regions to define Nitrate Vulnerable Zones (NVZ). Since 2004, Italy has increased its vulnerable zone size. As there is a groundwater pollution problem, the pilot area has been defined as NVZ by the Lazio regional government.

8.7.3 Water framework directive and national implementation (D.L.152/2006)

The WFD contributes to preserving, protecting and improving the environmental quality and also the prudent and rational utilization of natural resources, introducing the concept of the Full Cost Recovery for water services.

This law implements at national level the WFD 2000/60/CE with a coherent and sustainable protection of waters, through an integrated approach of different aspects of management and ecology to river basin scale. The third Part of this law (related to the water resources management) introduce significant modifications:

- It assembles the previous laws already present on the Italian regulatory framework (L.183/89, L.36/94, D. L.gs152/99).
- The Italian territory was divided into 8 river basin districts.
- Reorganization of the Jurisdiction in matters relating to soil protection and water resources planning and management.
- Introduction of new tools for planning and managing water resources – the water management plan - for each of the 8 river basin districts

8.8 User requirements

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2.

During the 1st Plenary meeting in October 2015 in Albacete (Spain) the institutional stakeholder Pasquale Nino represented the "Consiglio per la ricerca in agricoltura e l'analisi dell'economia agrarian" (CRAE), a public research institution under the surveillance of the Ministry of Agricultural, Food and Forestry Policies.

CREA is monitoring the water use in agriculture and makes research on cost recovery of environmental costs. FATIMA may help in these aspects with determination of crop water requirements

Pasquale Nino stated that an integration of environmental policies into agricultural policies is necessary for a better use of the inputs water, energy and nutrients. FATIMA may provide support in this topic.

8.9 Campaign plan

8.9.1 General purpose of the campaign

The general purpose of the campaign is to provide users (farmers) with FATIMA products (maps of nutrient & water requirements and yield) in near-real time (48 hours after satellite overpass). This includes predictions for 1 week ahead (water) / for growing season (nutrients).

The regional team in Italy is experienced because they participated in various projects (e.g. Pleiades, SIRIUS, Irrisat) where already tools for irrigation management have been developed. Their experiences are apparent in effective organization of stakeholders and farmers are ready to test the new products.

8.9.2 Field trials

8.9.2.1 Purpose

The field trials shall establish a ground truth for calibration and evaluation of the EO products (maps of water, nutrients, yield). A further goal is the development of correlation algorithms between nutrient diagnosis and soil moisture with EO satellite imagery observations.

From farmer's perspective, a more sustainable N-fertilization shall be established to reduce nitrate leaching. The field experiments will include tomato and winter wheat.

For the tomato crop, we propose to increase the level of complexity of the traditional system of production by cultivating vetch (or other legume to be green manured) in the autumn-winter period before tomato transplanting together with an organic amendment like compost.

In order to evaluate the effective improvement of the sustainability of the proposed modified system of production, a field experiment in which the experimental factor is the origin of N (from synthetic nitrogen fertilizer and from green manure + compost) will be carried out. For the wheat crop, in order to reduce the potential nitrate leaching of the traditional system of production, we propose to compare three different types of N fertilizer (synthetic, slow release and organic N fertilizers). In order to evaluate the effective improvement of the sustainability of the proposed modified system of production a field experiment in which the experimental factor is the N type of fertilizer utilized (synthetic, slow release and organic N fertilizers) will be carried out. The Green manure cover crop type will be the Field bean (Vicia faba L.).

Compost will come from Local industry production, nearby Tarquinia. This is a compost derived by the re-use of vegetal residues coming mainly from local agro-forestry activity. The rate of Compost to be applied in the Experiment A will be of 15 tons per hectare, at the beginning of the Trial, that is just before planting the "Green Manure" Cover Crop.

8.9.2.2 Design

The varying factor for both crops is source of N-fertilizer. Tomatoes will be fertilized with 1) synthetic N-fertilizer and 2) green manure from field beans (Vicia Faba L.) as pre-crop and compost. Winter wheat will receive 1) synthetic fertilizer, 2) slow release fertilizer and 3) organic N fertilizers.

Compost is produced in a local company in Tarquinia derived from residues of vegetables and 15t/ha will be applied before the fields beans are planted. The trials will start in the end of October 2015 for both crops.

For a detailed description of tested parameters see D3.3.1.

8.9.2.3 Results

8.9.3 Description and purpose of EO

8.9.3.1 Purpose

The goals of the EO campaign are to

- obtain maps of nutrient & water requirements every 1-2 weeks (Landsat8);
- obtain maps of yield (prediction & end of season);

- maps of nutrient & water requirements at higher spatial resolution (Sentinel2 as soon as available 10m, RapidEye 5m, WV-2 2m) at selected dates of strategic importance in crop phenology;
- analyze sensitivity of maps to different image resolution.

8.9.3.2 Design

The existing system for irrigation support allows the monitoring of crop growth and the shows the water demand of the plant. It reaches different stakeholder from government authorities to single farmers and can be accessed through a web-application.

The final decision on the web-GIS tool that will be developed in FATIMA has not yet been taken and depends on the farmer's demand.

8.10 Pictures

Figure 56: Wheat field

Figure 57: Irrigated tomatoes

9 Menemen Plain (Turkey TR)

The Menemen Plain in the Lower Gediz River Basin is located in the Province Izmir. The area is intensively agriculturally used – the main crops are cotton, wine and maize - and irrigated mainly by furrow irrigation. The main challenges are increasing pressure on the water resources and pollution of water and soil. Frequent drought conditions lead to an over-exploitation of groundwater and endanger the income of farmers, who follow a strategy of risk minimization by applying high water and fertilizer dosages.

FATIMA will contribute to save the soil and water resources for the future generation by providing a tool for more precise fertilizer application.

9.1 Overview

9.1.1 Geography

The Menemen Plain is located in the western part of Turkey in the Aegean Region (Province Izmir). The main river in the region is the Gediz river, which flows from east to west into the Aegean Sea. Izmir with around 4,1 million inhabitants is the major city in the region.

The pilot area itself is located 30 km north of Izmir and has a size of 20.553 ha, of which 80% are agriculturally used. The irrigated covers 13.800 ha and irrigation is the main water consumer in the region. 150.000 people live in the pilot area in the cities Menemen, Maltepe and Seyrek.

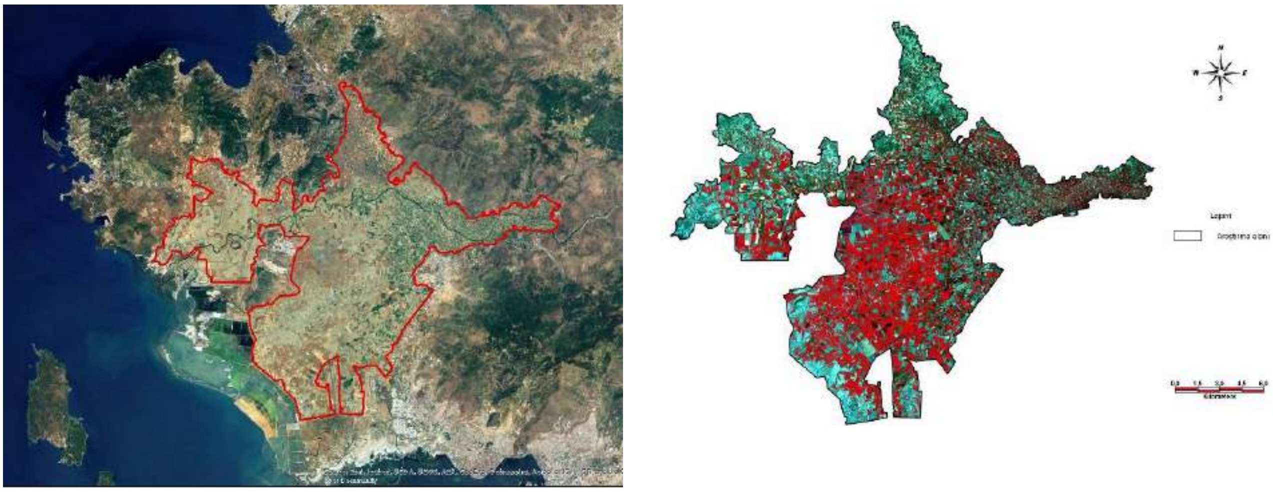

Figure 58: Maps of the pilot area TR

9.1.2 Farm structure

The average irrigated plot size in the pilot area is small with 1.3 ha. The government has already taken measures to avoid the further splitting of fields.

9.1.3 Climate

The pilot area features hot Mediterranean climate with dry summers and an annual precipitation of 540mm, which occurs mainly in winter.

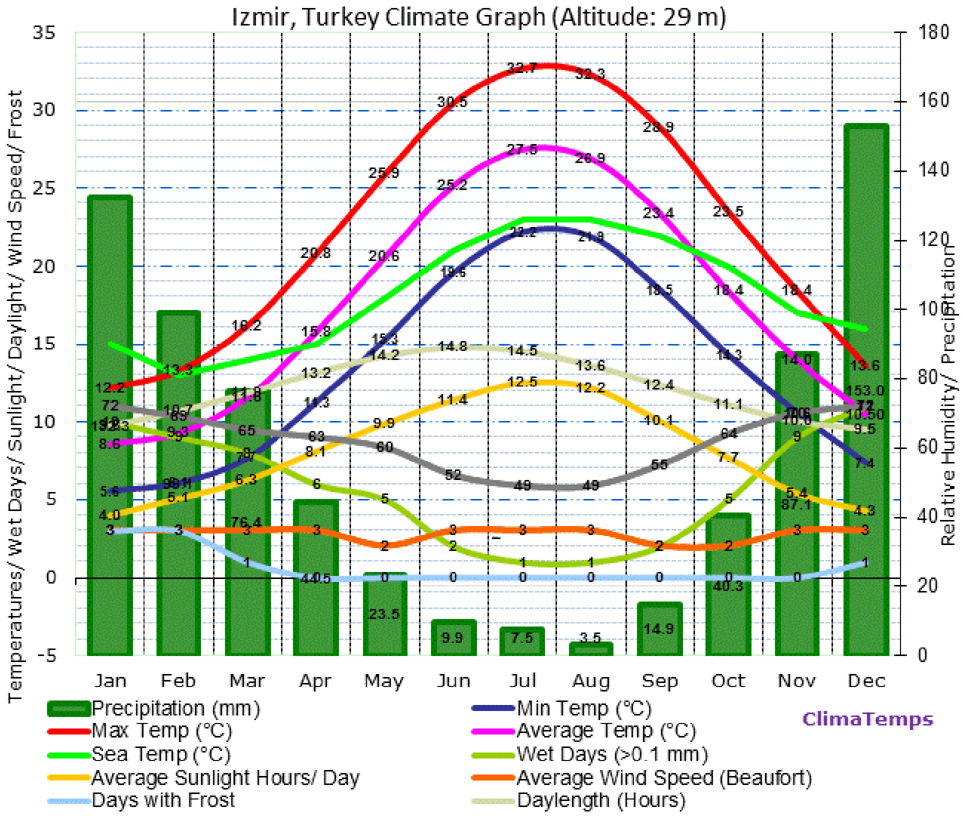

Figure 59: Climate chart of Izmir, Source: http://www.izmir.climatemps.com/, last access on 3/31/2016,1:36 PM

9.2 Main Challenges

The main challenges are increasing pressure on the water resources and pollution of water and soil. Frequent drought conditions lead to an over-exploitation of groundwater and endanger the income of farmers.

9.3 Major crops

Table 21: Major crop types in the pilot area TR

	Crop	total area (ha) within Pilot Area	month of sowing / harvest (months of irrigation if applicable)	average yield (kg/ha)
Largest area	Cotton	8500	Late April, Early May/October	6000
2nd largest	Vineyard	3000	--	20000
3rd largest	Corn (grain I,II; Silage I, II)	2000	April& June/October	15000, 11000, 50000, 40000
4th largest	Wheat	1500	November/June	5870
5th largest	Tomato	1200	April& June	60000

9.4 Current practices related to water and fertilizer use

The general strategy of farmers in this region is "risk minimizing" in terms of achieving the desired yield. They do it by "over-fertilizing" and "over-irrigating" as they fear to lose yield.

Table 22: Average irrigation and fertilizer amounts applied in the pilot area TR

Crop	average irrigation volume (m^3/ha)*	average fertilizer application (kg N per ha; organic or mineral; solid or liquid)
Cotton	6000	160
Vineyard	4500	140
Corn (grain I,II; Silage I, II)	7500	230
Wheat	1500	180
Tomato	10000	200

*Theoretical values. Realized irrigation water use 7000-7200m^3/ha on average in the water scheme area.

9.5 Water supply and wastewater treatment

River water from the Gediz river is the main source of water for irrigation. Less than 10% of the plots in the pilot are irrigated with groundwater.

9.6 Irrigation infrastructure

Almost all plots (98%) are irrigated with furrow irrigation. Only for vineyards and vegetables drip irrigation systems are installed.

9.7 Main policies relevant for rural development

9.7.1 Regulation for protection of waters against nitrate pollution stemming from agriculture, 2004 (similar to Nitrate Directive)

Similar to the EU countries, Turkey has assigned NVZs and Potentially Nitrates Vulnerable Zones (PNVZs). In Turkey, works for the implementation of EU ND have been ongoing since 2004. The fact that Turkey has much bigger and uneven area compared to that of the other EU member states shall cause that some differences will be encountered in practice and control. Moreover, influence on the waterworks management by more than one institution in Turkey might create problems in the implementation of the directives regarding water and it might cause an authorization complexity in the implementation of the ND. Due to the fact that Turkey has diverse climate, geography and topography, high diversification is observable in the agricultural products. Increase in the population of Turkey, as also experienced throughout the world, caused demand for food, increase in the agricultural intensity, and requirement for several environmental arrangements. In some provinces, nitrate pollution stemmed from agricultural activities has significant pressure on surface and underground water. It is aimed at reducing these pressures by implementing Nitrate Directive and ensuring its sustainability by improving current water quality status (Yildirim and Demir, 2012)

9.7.2 Regulation for agricultural basins, 2010

The agricultural basin model has been formed in order to plan and increase production while protecting natural resources and implement an efficient and rational agricultural support policy based on agricultural basins. Within this scope, totally 30 agricultural basins have been identified through evaluation of approximately 528 million data based on climate, soil, topography, land classes and land usage types. For each basin, the strategic, specific, supply deficit and competitive products have been selected. The maps have been drawn according to agricultural basins. The agriculture inventory has been elaborated based on the Agricultural Basins. The products to be supported have been identified by determining the regions where the products are most efficiently produced using the Agricultural Basins data. Menemen plain, the pilot area is in the Coastal Aegean Basin. The crops wheat, maize and cotton, we will work on the FATIMA Project are also in the list of product to be supported.

9.8 User requirements

For an overview of relevant stakeholders in the pilot area see Deliverable D1.1.2.

During the 1st Plenary meeting in October 2015 in Albacete (Spain) the institutional stakeholder Dilek Kahraman represented UTAEM. UTAEM is a governmental agricultural research and training institute and an institutional end user of FATIMA tools in the area. She highlighted the problem of small plots as many fields are smaller than 1ha. The farmers in the area mainly use furrow irrigation without metering the used amounts of water, the application of irrigation advisory service may be difficult in the pilot area. Farmers pay a flat rate of 10€ per 1000m² of field they are irrigating.

She thinks that development of a fertilizer application tool may be more promising as farmers now apply high amounts of fertilizer as they fear to lose yield if they apply less. It is difficult to convince farmers; they first want to see results before they change their habits. She believes as institutional end-user her institute should apply and use the FATIMA tools to lead farmers around them.

9.9 Campaign plan

9.9.1 General purpose of the campaign

It is planned to conduct the main campaign in 2016 and 2017; preparatory activities were done in 2015. During the campaign, maps of nutrients and water requirement are planned to be provided to manage variation in N and irrigation water requirement in small plots and spatial and temporal scaling would be focused.

9.9.2 Field trials

9.9.2.1 Purpose

The purpose of the field trials is to

- establish a ground truth for calibration & evaluation of EO products (maps of water, nutrients, yield)
- establish the range of spatial variability & N-input sensitivity (subplots of 2 N inputs for cotton plot.

9.9.2.2 Design

One intensive and 12 extensive cotton plots were monitored. In intensive cotton plot 2 N (N & N - 5%) levels were implemented. Levels and quality of water table were monitored. On the other hand, one intensive maize plot was monitored. Dates important in crop phenology were observed especially for high resolution images.

9.9.2.3 Results

Soil and plant samples were collected according to calendar of Landsat8. Geo statistical calculations for soil parameters in the field and in the area were carried out and the maps were produced by using satellite images. Details of the tested parameters for soil and plant are reported in D3.3.1.

Requirements for non-invasive plant measurement instruments (chlorophyll meter, canopy/LAI meters) were identified and purchased.

The results attained are estimations of irrigation requirement for regional level might be much more useful than in field irrigation management. The tools of FATIMA for soil and plant fertility management will be more interesting for individual farmers. High resolution satellite images are important for monitoring soil fertility and plant conditions in small plots.

9.9.3 Description and purpose of EO

9.9.3.1 Purpose

During the regional meeting it turned out that it is very important to prove/demonstrate in this area that the EO data are appropriate for achieving FATIMA objectives in the local conditions. Reasons that support the use of EO data are i.a. a cheaper price compared to the similar information gathered from sensors and ii. favourable meteorological conditions of this pilot area as there are hardly clouds during the summer months.

The fertilizer use efficiency in field and the irrigation scheme level will be increased by the help of FATIMA tools. On the other hand, although irrigation management would not be a focal point for the farmers individually, it would be an effective tool to manage irrigation water in regional scale for the water user association (Deliverable D1.1.2).

The goals of the EO campaign are to

- obtain maps of nutrient & water requirements every 1-2 weeks (Landsat8);
- obtain maps of yield (prediction & end of season);
- compare maps of nutrient & water requirements at higher spatial resolution (Sentinel2 as much as available 10m, RapidEye 5m, WV-2 2m) to lower resolution (Landsat8) maps at selected dates of strategic importance in crop phenology and identify up/ down scale methods/ algorithms;
- feed SPIDER and crop model(s) (AQUACROP/ DSSAT) for simulations in season dynamics and mid- term scenarios.

9.9.3.2 Design

The field trails for precision farming will be conducted in 2 locations. One of them will be on one of UTAEM's experimental fields, 5ha, for wheat and maize. The application of fertilizer and irrigation will be done according to soil analyses and sensors results. On the field, wheat (rainfed) and maize will receive N in 3 different origin:

chemical, manure, slow release. Irrigation will be carried out according to sensors for maize and irrigation requirement for the next week will be estimated by FATIMA tools. Winter wheat and maize experimental area will be the same and they will follow each other. In the other location, there will be 3 subplots of the applications for cotton.

UTAEM has commercial production fields nearby these experimental plots and intensive monitoring will also be done on one of these fields. Additionally, 15 farmer fields will be monitored extensively. In total 20 (5+15) fields will be aimed to monitor both as intensive and extensive plots.

The trials will be started in November 2015 (wheat), at the beginning of May (cotton) and in mid-June (maize).

The test parameters for soil and plant will be the same in D3.3.1 and monitoring parameters for the weather will be as in D2.3.1. EO data for the area will be used on SPIDER platform for crop growth monitoring, ex-ante assessments for irrigation water requirements and nutrient input.

9.10 Pictures

Figure 60: Turkish pilot area

Figure 61: Cotton in TR

Figure 62: Maize in TR

Figure 63: Irrigated maize in TR

9.11 References

Yildirim, H.B, Demir, S.(2012) Implementation of the EU Nitrates Directive in Turkey, Batı Akdeniz Tarımsal Araştırma Enstitüsü Derim Dergisi 29(1) 2012 p.48-58

10 Conclusions

This deliverable highlights the characteristics of the pilot areas with their special features and different working focus (Table 5 and Table 6). In terms of size, the pilot areas vary between small cooperatives (CZ), small regions (AT, FR, IT, TR) to large governmental units with more than 1 million ha (ES, GR). Due to the differences in size, the percentage of agricultural land naturally also varies a lot – from 36% (ES) to 89% (CZ).

Even though physical differences are large, the pilot areas face similar problems. Due to high fertilizer use, the groundwater, which serves as main water source in almost all areas, shows high nitrate levels. All pilot areas are located at least partly in nitrate vulnerable zones. The main goal of FATIMA is to make a step forwards towards a more sustainable agriculture in intensively farmed areas. A tool for more efficient use of fertilizers is therefore one of the main products that will be developed for the farmers.

In all countries, farmers aim at reducing the costs of input resources. Not only fertilizer, but also water plays an important role in the pilot areas. With the exception of the Czech Republic, in all pilot areas irrigation is practiced and makes the production of water intensive crops such as vegetables, tomatoes and cotton possible. The percentage of irrigated plots ranges from 10% in Italy to even 67% in Turkey.

Most pilot areas feature annual precipitation of 550-700 mm, but this amount of water is often mainly concentrated during the winter months and a water deficit occurs during summer, when crops require the highest amounts of water. Therefore, a more efficient application of the available water resources can increase the yield of farmers and prevent the groundwater bodies from depletion.

The FATIMA campaigns are based on the use of satellite Earth observation data such as Sentinel-2 and Landsat-8 and other types of remotely sensed data (from drones or ground sensors) and aim at providing the farmers with specific information for single plots up to farm and regional scale. In Greece and Turkey, the size of single plots is often less than 1 ha which will require a more intensive use of ground sensing devices and very high spatial resolution Earth observation data (e.g. World-View 2). The structural form of agricultural systems in Greece and Turkey can be traced back to long traditions of how land is passed on to the next generation and it will be analysed more in detail in WP4 (Policies).

In all pilot areas, delivery of information and demonstration (demo campaign) with users will be based either on SPIDER (i.e. in ES, GR, TR, CZ, FR) or Irrisat (AT, IT) webGIS systems. In each pilot, depending on previous experiences and available local know-how, the focus is either on setting up the system in those pilot areas that did not use the webGIS before (i.e. in GR, TR, CZ, FR) or on improving and adapting existing features (i.e. in AT, IT, ES) for the new FATIMA tools. In addition to the EO demo campaign, the teams in the different pilot areas work focusing not only on demonstration activities but also on the calibration and validation of methods (experimental campaign). In Austria, different nitrogen rates are tested in experimental plots and then compared with the observations from the satellite data. In Italy, there is a focus on the testing of different types of nitrogen fertilizers from industrial fertilizer to compost. In Spain, the experiments on upscaling VRT to commercial scale will be continued, whereas in Greece the development of a VRT applicator is the main goal. In the Czech Republic, VRT in combination with sensors and lysimeters is tested and in France, different crop growth models are applied.

This summary of the different pilot areas shows that even though all of them feature different physical conditions and focus on different crops, all face similar problems and aim at a decreased input of water and/or nitrogen fertilizer. The package of experiments connected to the implementation of earth observation technologies and the development of the WebGIS will give an integrate response to the most urgent problems of European agriculture.