D6.1: Pilot plan and evaluation methodology

WP6 – Pilot operation and evaluation

Authors: Dragutin Protic, Evangelos Anastasiou, Milan Kilibarda, Branislav Bajat, Ivan Aleksic, Zisis Tsiropoulos, Spyros Fountas

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 687412.

Disclaimer

Copyright message

Document Information

Grant Agreement Number	**687412**	**Acronym**	**APOLLO**	
Full Title	Advisory platform for small farms based on earth observation			
Horizon 2020 Call	EO-1-2015: Bringing EO applications to the market			
Type of Action	Innovation Action			
Start Date	1st May 2016	**Duration**	34 months	
Project URL	http://APOLLO-h2020.eu/			
Document URL	-			
EU Project Officer	Iulia Simion			
Project Coordinator	Polimachi Simeonidou			
Deliverable	D6.1: Pilot plan and evaluation methodology			
Work Package	WP6 – Pilot operation and evaluation			
Date of Delivery	**Contractual**	M14	**Actual**	M14
Nature	R	**Dissemination Level**	PU	
Lead Beneficiary	DRAXIS Environmental SA			
Lead Author	Dragutin Protic	**email**	protic@grf.bg.ac.rs	
	UBFCE			
Other authors	Milan Kilibarda, Branislav Bajat, Ivan Aleksic, Evangelos Anastasiou, Zisis Tsiropoulos, Spyros Fountas			
Reviewer(s)				
Keywords	Evaluation, user experience, user acceptance, pilot plan			

Document History

Version	Issue Date	Stage	Changes	Contributor
1.1	07/06/2017	Draft	Initial version sent to reviewers	UBFCE

Table of Contents

This project is co-funded
by the European Union

Table of Figures

Table of Tables

Glosary

Abbreviation/Acronym	Meaning
EO	Earth Observation
LAI	Leaf Area Index
WP	Work Package
DoW	Description of Work
EOU	Ease of Use
TAM	Technology Acceptance Model

Table 1 Glossary

This project is co-funded
by the European Union

Executive summary

This document reports on the development of a detailed plan on APOLLO pilot execution and methodology that will be followed in order to evaluate APOLLO platform. The methodology includes using evaluation criteria, namely user experience, user acceptance and benefits of using the APOLLO services that will be measured by a number of indicators. According to the adopted User Centered Design approach, the evaluation is a part of the development process aimed to ensure that the optimal final product ready for commercialization is delivered. Pilot will be executed in three phases: alpha, beta and pilot. The end users will be involved in trials and testing the platform in each of the phases while the platform itself will be gradually improved from one phase to the next according to the users' feedback and evaluation data. The report also defines the roles and responsibilities of the project partners, plan for training material design, ethical and legal issues and potential risks and mitigation.

Introduction

One of the main objectives in Apollo project is to offer high quality services to farmers that will help them increase their productivity. The offerings can be summarized in 6 different services i) Tillage scheduling, ii) Irrigation scheduling, iii) Crop growth monitoring, iv) Crop yield estimation, v) Weather forecasting (additional service) and vi) Management zones (additional service). Crop biomass is one of the biophysical parameters of crops that will be produced to support two of the services, namely crop growth monitoring and crop yield estimation. The services will be tested in three pilot areas: La Mancha (Spain), Pella (Greece) and Ruma (Serbia).

This report is aimed to describe a detailed pilot deployment plan in order to ensure the successful execution of the pilot. The main objective of the pilot is to assess the APOLLO solution. The other objective is to provide users' feedback, which will help the development team to produce the optimal solution that will be sustainable after the project is finished. Furthermore, the information collected through evaluation will be used to build strong business case for APOLLO products. In order to maximize effects of collecting users' feedback and effects of using APOLLO services on crop production and agricultural practices, a detailed methodology for evaluation of APOLLO platform has been developed.

The document is structured in the following way. The first section defines methodology for evaluation of APOLLO platform. In the second section, the plan for pilot execution is presented. In section three, ethical and legal issues that can arise during the evaluation are identified. Section four is dedicated to possible risks and remedial actions. Section five presents the conclusions.

1 Evaluation methodology

1.1 Evaluation strategy

Evaluation is a systematic determination of a subject's merit, worth and significance, using criteria governed by a set of standards. It can assist an organization, program, project or any other intervention or initiative to assess any aim, realisable concept/proposal, or any alternative, to help in decision-making; or to ascertain the degree of achievement or value in regard to the aim and objectives and results of any such action that has been completed. The primary purpose of evaluation, in addition to gaining insight into prior or existing initiatives, is to enable reflection and assist in the identification of future change[1].

In development of the APOLLO platform User Centered Design approach has been applied. It means that the potential APOLLO users have been placed at the center of the design process from the stages of designing the system requirements to implementing and testing the product.

The APOLLO User Centered Design process consists of several phases, namely: definition of user needs, definition of technical requirements, system architecture, development and evaluation (Fig.1).

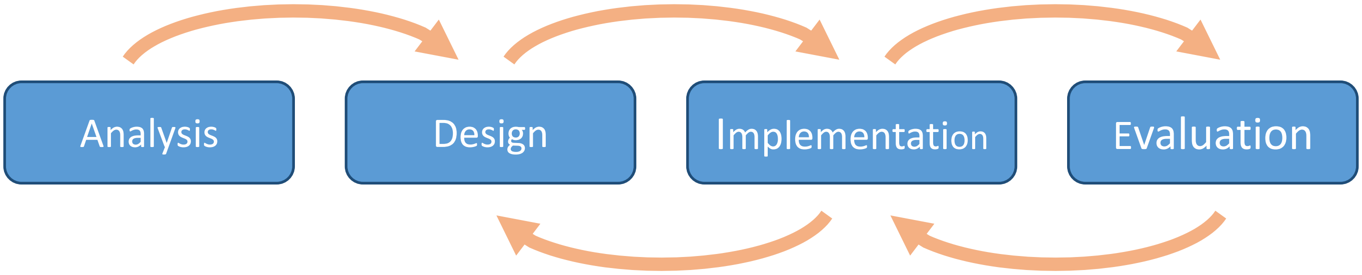


Figure 1: User Centered Design

The aims of APOLLO evaluation process are:

a) to assess if the main project objective, namely to provide a suite of farm management advisory services specifically designed to address the needs of small farmers, is achieved

b) to provide end-users feedback in the process of platform development

c) to enable sustainable commercial exploitation of the project outcomes after the end of the project.

The APOLLO evaluation methodology will apply verification and validation of the platform:

---

[1] https://en.wikipedia.org/wiki/Evaluation

- **Validation** means testing if the product meets users' needs. It will provide answer to the question: Are we building the right product?
- **Verification** means testing if the product has been built according to the requirements and design specifications. It will provide answer to the question: Are we building the product right?

1.2 Criteria for evaluation

The value of APOLLO platform will be assessed against a set of criteria.

- **Criterion**: a standard something is judged by.

For each criterion a set of indicators will be defined that will describe how the APOLLO platform fits to it.

- **Indicators**: parameters which can be measured and correspond to a particular criterion.

The following evaluation criteria will be used in APOLLO project:

- User experience
- User acceptance
- Benefits for end-users from using APOLLO services

1.2.1 User experience

According to ISO 9241-210 standard, User experience can be defined as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" -.

User experience generally reflects users' feelings when they use a technology. It depends on usability and system performance.

ISO 9241-11 standard defines usability: "This part deals with the extent to which a product can be used by specified users to achieve specified goals with effectiveness (Task completion by users), efficiency (Task in time) and satisfaction (responded by user in term of experience) in a specified context of use (users, tasks, equipments & environments)." Nielsen (2012) determined that usability is defined by five quality components: learnability, efficiency, memorability, errors and satisfaction. Those can be developed in the following way:

- Learnability (How easy is it for users to accomplish basic tasks the first time they encounter the design?),
    - Help & support – I can get help when I need it
- Efficiency (Once users have learned the design, how quickly can they perform tasks?),

- Memorability (When users return to the design after a period of not using it, how easily can they re-establish proficiency?),
  - Consistency – I don't have to learn new tricks
- Errors (How many errors do users make, how severe are these errors, and how easily can they recover from the errors?),
- Satisfaction (How pleasant is it to use the design?)
  - Control – I am in charge
  - Navigation-I can find my way around
  - Feedback – I know what the system is doing
  - Language – I understand the terminology
  - Visual clarity – I can recognize things and the design is clear and appealing

Experience of the APOLLO platform users will be measured by the following indicators:

- Perceived ease of use of APOLLO platform
- Perceived quality of information provided by APOLLO services
- Perceived learnability of APOLLO platform tools
- Perceived performance (error occurrence, efficiency)
- Perceived satisfaction

1.2.2 User acceptance

User acceptance can be defined as the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support (Dillon and Morris, 1996). Acceptance has been conceptualized as an outcome variable in a psychological process that users go through in making decisions about technology. User acceptance has direct impact on the sustainability of a technology.

There are number of technology acceptance models based on psychology, information systems and sociology that are used to explain the motive of users to accept and use IT solutions (Rasimah et al., 2011). According to the Theory of Reasoned Action (Ajzen & Fishbein, 1980), use or rejection of technology is determined by one's intention to perform the behavior, and this intention is influenced jointly by the individual's attitude and subjective norm, defined as "the person's perception that most people who are important to him (sic) think he should or should not perform the behavior in question" (Dillon and Morris, 1996). Attitude toward a behavior is determined by beliefs about the consequences of the behavior and the affective evaluation of those consequences.

This project is co-funded by the European Union

The widely used model aimed to predict user acceptance is the Technology Acceptance Model (Davis, 1993), derived from the Theory of Reasoned Action (Dillon and Morris, 1996). The goal is “to provide an explanation of the determinants of computer acceptance that is generally capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified” (Davis, 1993). According to the Technology Acceptance Model, user acceptance of any technology is determined by two factors: perceived usefulness and perceived ease of use (Figure 3).

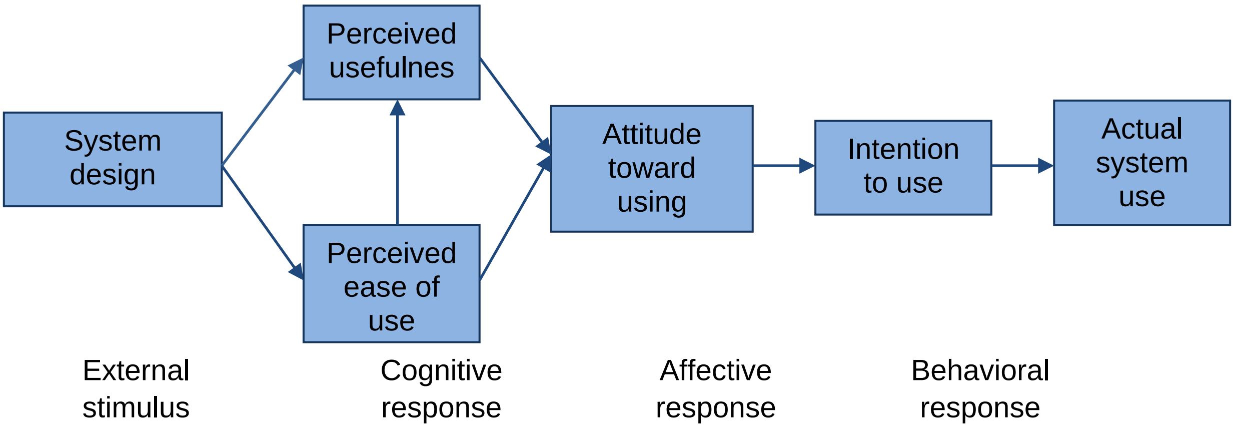


Figure 2: Technology Acceptance Model (from Davis, 1993)

Dillon and Morris (1996) gave an interpretation of the model: “Perceived usefulness (U) is defined as the degree to which a user believes that using the system will enhance his or her performance. Perceived ease of use (EOU) is defined as the degree to which the user believes that using the system will be free from effort. Both U and EOU are specific perceptions and are anchored to specific beliefs users hold about the system. According to TAM, U and EOU have a significant impact on a user's attitude toward using the system (A), defined as feelings of favourableness or unfavourableness toward the system. (Thus, attitude is a general construct not tied to any specific beliefs about the technology.) Behavioral intentions to use the system (BI) are modeled as a function of A and U. BI then determines actual use.”

To measure acceptance of a specific technology, usually many additional indicators (other than perceived usefulness, perceived ease of use and attitude), specific to the technology and to the users group, are used: social influence, perceived benefits, perceived price level, perceived contents quality etc.

User acceptance of the APOLLO platform will be measured by the following indicators:

- Perceived usefulness (the degree to which a user believes that using APOLLO services would improve current agricultural practices);
- Attitude (the degree to which the system causes a positive or negative attitude to its user);
- Intention (the degree a user is determined to use APOLLO services);
- Perceived value (the degree to which a person believes that it is worth investing in APOLLO services).

1.2.3 Benefits of using the APOLLO services

Aim of APOLLO project is to support small farmers decisions during the whole cultivation period and for different types of crops (annual and perennial) and crop systems (rainfed and irrigated). Therefore, APOLLO platform offers four main services (namely tillage scheduling, irrigation scheduling, crop growth monitoring, crop yield estimation) and two additional services (weather forecasting and management zones) for this reason.

Tillage is the practice of preparing the soil by mechanical agitation. However, if soil is tilled when soil water content is more than optimum, then large clods can be produced and soil structural damage occurs, impeding plant emergence and leading to uneven stands. If soil water content is less than optimum, then tillage requires excessive energy and dust is created resulting to severe soil degradation, a major threat to agricultural sustainability and environmental quality. These problems can be minimized if the soil is scheduled to be tilled at the optimum water content (Dexter et al., 2005). In addition, by measuring soil workability at field level, the farmer can estimate if it is possible to apply soil tillage while at sub-field level the farmer can estimate if there are spots on his/her fields where the soil cannot be treated (e.g. mudding spots). According to Servadio et al. (2016), fossil duel energy requirements may be higher than 25% if tillage operations applied in low soil moisture conditions. Moreover, this had a main effect in slip and tillage operation efficiency where it was higher and lower in low soil moisture conditions accordingly. Based on the aforementioned, APOLLO's tillage scheduling service will have a major impact on farm profitability by decreasing fuel costs, decreasing tillage operation time due better soil conditions for tillage operations. Additionally, this service will also provide environmental benefits such help in minimizing soil degradation, sustaining soil fertility and reducing fossil fuels CO_2 emissions.

Irrigation is the artificial application of water to the land or soil. Irrigation has proved its value through history. The main benefits of irrigation are (i) increased agricultural production, (ii) stable and reliable yields, (iii) continuous cultivation and (iv) decreased risk for crop failure because of drought. Specifically, according to Broner (2005) irrigation scheduling:

- enables the farmer to schedule water rotation among the various fields to minimize crop water stress and maximize yields;
- reduces the farmer's cost of water and labor through fewer irrigations, thereby making maximum use of soil moisture storage;
- lowers fertilizer costs by holding surface runoff and deep percolation (leaching) to a minimum;
- increases net returns by increasing crop yields and crop quality;
- minimizes water logging problems by reducing the drainage requirements.
- assists in controlling root zone salinity problems through controlled leaching;
- results in additional returns by using the “saved” water to irrigate noncash crops that otherwise would not be irrigated during water short periods;

As a result, irrigation in agriculture is essential for securing plant growth but is the major consumer of fresh water globally. So, the need for better water use efficiency through better irrigation scheduling is in great priority worldwide. Zotarelli et al. (2009) found that irrigation scheduling achieved up to 51% in water savings compared to conventional irrigation in a tomato crop without decreasing crop quality and yield. Hassanli et al. (2009) achieved up to 63% water savings in corn crop in an arid region without having any effect in corn yield. APOLLO's irrigation scheduling service will have a major economic and environmental impact by increasing water use efficiency in crops and thus achieving water, nitrogen and energy savings. In addition, APOLLO’s irrigation scheduling service will reduce crop production costs due to the aforementioned savings.

Crop growth monitoring is the process of monitoring the crop status from emergence to harvest. Crop growth monitoring is also of great significance in order to obtain essential crop condition information such as status and growth trend during its biological circle. Through crop growth monitoring it is easy to monitor changes on the crop status because of abiotic factors such as water stress and biotic factors such as insect infestation (Nichols, 1997). It also helps for delineating different productivity zones at sub-parcel level for variable rate application of fertilizers and plant protection products. Nowadays, the determination of crop growth is made through the use of costly and time consuming aerial or field surveys that include the use of many different instruments such as hyperspectral sensors. APOLLO platform’s crop growth monitoring service will offer satellite based crop growth monitoring as a cheap and high accurate alternative for helping farmers and crop consultants identify accurate and on time anomalies in crop growth. This will result indirectly to cost savings due to lesser time spending for crop scouting, lesser amount of pesticides and fertilizers according to crop needs and efficient infestation control due to timely crop scouting.

Crop yield estimation is the process of estimating a yield of a crop before harvest. The benefits of this service are very significant for the farmer and the agronomist. Crop yield estimation is important for the analysis and comparison of field productivity but also it allows farmers to decide at farm level whether selling the product or leading it to the storage andfor defining the logistics activities for enabling an effective transfer from farm to the industry. Currently crop yield estimation is mainly done through time consuming, expensive field sampling, which includes the measurement of biomass weight and grain size. APOLLO’s crop yield estimation service will provide farmers with estimations on crop yield in order to arrange better transport logistics of their production or to select to store their production and sell it later.

1.3 Evaluation of APOLLO services

1.3.1 Experimental designs

APOLLO project will evaluate the usefulness of each service of the platform using quantitative and qualitative analysis. In order to do this, field trials will be conducted in the three pilot sites of APOLLO project for each crop. Main aim of them is to compare the usefulness of each of APOLLO services to current farming practices. However, not all APOLLO services can be compared with current practices. Specifically, only tillage scheduling and irrigation scheduling services can be evaluated with field trials, because they are the only services that provide farmers with advices on tillage and irrigation accordingly. Based on this and on the fact that some of the crops that are studied in APOLLO project framework, are not irrigated the following methodologies for establishing field experiment designs have been developed.

In rainfed crops the field will be splitted in half in which the one part (namely Reference plot) will follow current agricultural practices in relation to tillage practices and the other will follow APOLLO platform’s tillage scheduling advices (**Error! Reference source not found.**).

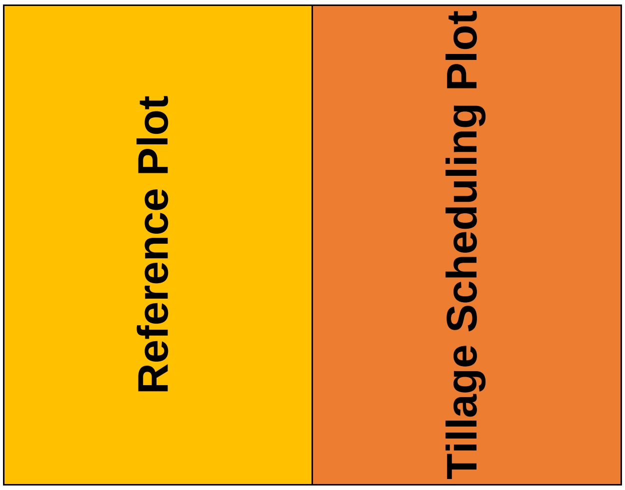


Figure 3- Example of field experiment design for tillage scheduling evaluation

Regarding the irrigated crops that will be studied in APOLLO project a different approach will be followed. In this case, the APOLLO services that will be evaluated are tillage scheduling service and irrigation scheduling service. These services are going be evaluated solely and combined with current agricultural practices for each crop. One field will be split in four plots in which one will be the reference plot, the other will follow advices coming from tillage scheduling service, the third will follow advices from irrigation scheduling service and the fourth will follow the advices from both tillage and irrigation scheduling services (**Error! Reference source not found.**). In case the fields are too small 4 fields will be selected that will be split in two plots. One plot will be the reference plot for each field while the other plot will follow advices coming from APOLLO's tillage scheduling service or APOLLO's irrigation scheduling service or both APOLLO's services (**Error! Reference source not found.**).

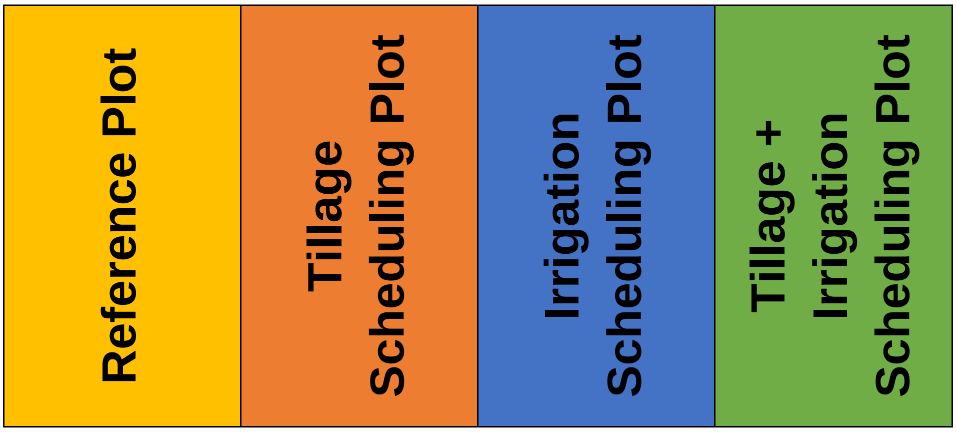


Figure 4- Example of field experiment design for tillage and irrigation scheduling services evaluation in the same field

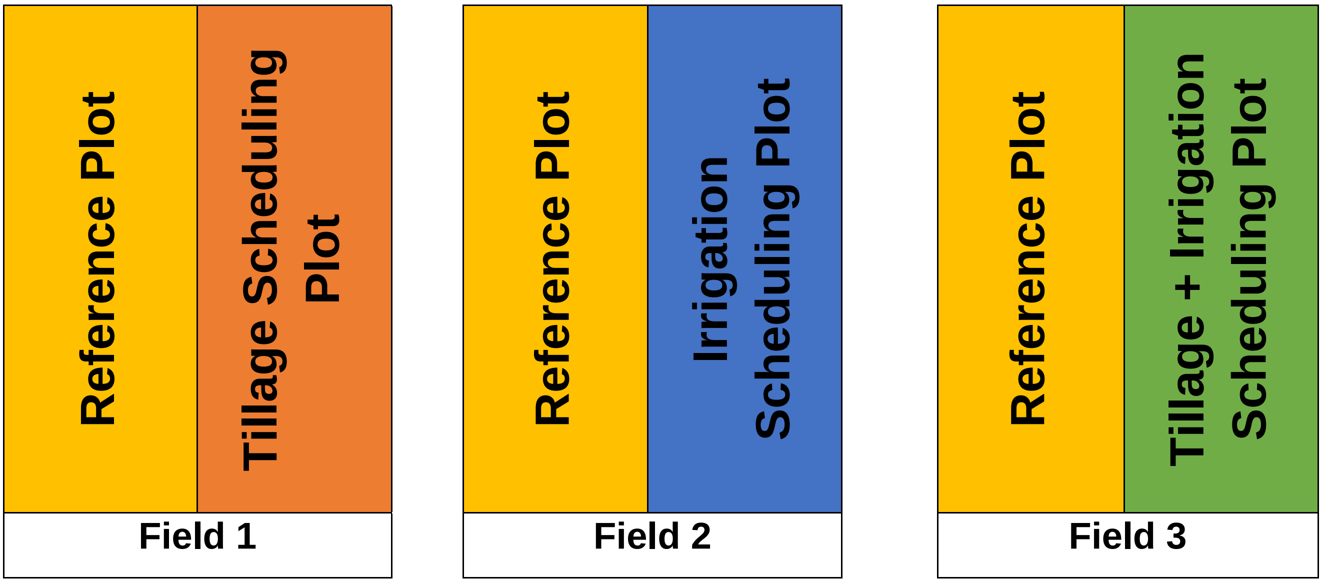


Figure 5-Example of field experiment design for tillage and irrigation scheduling services evaluation in different fields

Both in rainfed and in irrigation crops the other two APOLLO services (namely crop growth monitoring service and crop yield estimation service) will be used as tools for evaluation in comparison with the reference plots.

1.3.2 Services evaluation methodology

Each APOLLO platform service will be evaluated using multiple approaches compared to the current farming practices for each crop. Specifically, tillage scheduling and irrigation scheduling services will be evaluated in terms of savings in inputs, in cost savings, in yield and quality increase and in income increase. Also, every service will be evaluated in terms of acceptance by APOLLO platform’s users through the use of questionnaire survey. Additionally, the crop growth monitoring service and crop yield estimation service will also be used for evaluating tillage scheduling and irrigation scheduling services.

1.3.2.1 Tillage scheduling service evaluation

An overview of the methods that will be followed for evaluating tillage scheduling service can be seen in **Error! Reference source not found.**.

Evaluation		Methodology	Scenario
#	**Description**		
1	Fuel consumption measurements	1. CANBUS measurements	Measurements through CANBUS for measuring the exact fuel consumption during tillage operations
		2. Fuel tank refill in gas station after the tillage operation	Quantity of fuel needed to fill up the tank to the maximum level

2	Survey	1. Questionnaire to farmers with reference plots	Compare APOLLO platform suggestions and farmers practices if tillage using APOLLO advice was applicable and more efficient compared to the reference pilot (e.g. Was the tillage operation using APOLLO advice more effective that the reference one? (scale of 1-5))
		2. Questionnaire to all APOLLO trial users	Compare APOLLO platform suggestions and farmers opinions if tillage is applicable during the days that they make primary tillage (e.g. how useful do you find tillage scheduling (scale of 1-5))
		3. Questionnaire to agronomists	Compare APOLLO platform tillage scheduling platform and agronomists current tillage advisory services (e.g. how useful do you find APOLLO's tillage scheduling products as a service for your clients (scale of 1-5))
		4. Questionnaire to agricultural cooperatives	Compare APOLLO platform tillage scheduling platform and agricultural cooperatives' current tillage advisory services (e.g. how useful do you find APOLLO's tillage scheduling products as a service for your members (scale of 1-5))
3	Yield and Quality	Yield and Quality comparison	Yield and Quality comparison between the plots
4	Vigor	Vigor comparison	Vigor comparison between the plots

Table 2 – Tillage Scheduling Service Evaluation Methodology

1.3.2.2 Irrigation scheduling service evaluation

An overview of the methods that will be followed for evaluating irrigation scheduling service can be seen in**Error! Reference source not found.**.

Evaluation		**Methodology**	**Scenario**
#	**Description**		
1	Survey	1. Questionnaire to farmers with reference plots	Compare APOLLO platform suggestions and farmers practices if irrigation using APOLLO advice was applicable and more efficient compared to the reference plot (e.g. Was the irrigation operation using APOLLO advice more effective that the reference one? (scale of 1-5))

		2. Questionnaire to all APOLLO trial users	Compare APOLLO platform suggestions and farmers opinions if irrigation advice is helpful (e.g. how useful do you find irrigation scheduling (scale of 1-5))
		3. Questionnaire to agronomists	Compare APOLLO platform irrigation scheduling platform and agronomists current irrigation advisory services (e.g. how useful do you find APOLLO's irrigation scheduling products as a service for your clients (scale of 1-5))
		4. Questionnaire to agricultural cooperatives	Compare APOLLO platform irrigation scheduling platform and agricultural cooperatives' current irrigation advisory services (e.g. how useful do you find APOLLO's irrigation scheduling products as a service for your members (scale of 1-5))
2	Yield and Quality	Yield and Quality comparison	Yield and Quality comparison between the reference plot and the plots that follow APOLLO irrigation scheduling advice
3	Irrigation Dose	Irrigation Dose comparison	Comparison of the irrigation doses between the reference plot and the plots that follow APOLLO irrigation scheduling advice
4	Crop Water Use Efficiency	Crop Water Use Efficiency comparison	Compares the amount of water that was consumed for producing 1 kg of crop product between the reference plot and the plots that follow APOLLO irrigation scheduling advice
5	Vigor	Vigor comparison	Vigor comparison between the reference plot and the plots that follow APOLLO irrigation scheduling advice

Table 3-Irrigation Scheduling Service Evaluation Methodology

1.3.2.3 Crop Growth Monitoring Service Evaluation

An overview of the methods that will be followed for evaluating crop growth monitoring service can be seen in**Error! Reference source not found.**.

Evaluation		**Methodology**	**Scenario**
#	**Description**		
1	Survey	1. Questionnaire to farmers with reference plots	Compare usefulness of crop growth monitoring products with farmer crop scout practices/opinion (e.g. a) Did you find crop growth monitoring service useful in your

			crop scout? (scale of 1-5), b) Do you believe that you can minimize crop scout cost using crop growth monitoring service?)
		2. Questionnaire to all APOLLO trial users	Compare APOLLO platform suggestions and farmers opinions if crop growth monitoring is helpful (e.g. how useful do you find crop growth monitoring (scale of 1-5))
		3. Questionnaire to agronomists	Compare usefulness of crop growth monitoring products with agronomist crop scout practices/opinion (e.g. a) Did you find crop growth monitoring service useful in your crop scout? (scale of 1-5) , b) Do you believe that you can minimize crop scout cost using crop growth monitoring service?)
		4. Questionnaire to agricultural cooperatives	Compare APOLLO platform crop growth monitoring and agricultural cooperatives' current crop growth monitoring advisory services (e.g. a) Did you find crop growth monitoring service useful in your crop scout? (scale of 1-5) , b) Do you believe that you can minimize crop scout cost using crop growth monitoring service?)

Table 4– Crop Growth Monitoring Service Evaluation Methodology

1.3.2.4 Crop Yield Estimation Service Evaluation

An overview of the methods that will be followed for evaluating crop yield estimation service can be seen in **Error! Reference source not found.**.

Evaluation		**Methodology**	**Scenario**
#	**Description**		
1	Survey	1.Questionnaire to farmers with reference plots	Compare usefulness of crop yield estimation products with farmer crop scout practices/opinion (e.g. a) Did you find crop yield estimation service useful in your harvest plan? (scale of 1-5))
		2. Questionnaire to	Compare usefulness of crop yield estimation

		all APOLLO trial users	products with farmer crop scout practices/opinion (e.g. a) Did you find crop yield estimation service useful in your harvest plan? (scale of 1-5))
		3. Questionnaire to agronomists	Compare usefulness of crop yield estimation products with agronomist crop yield estimation services /opinion (e.g. How useful do you find crop yield estimation products as a service for your clients (scale of 1-5))
		4. Questionnaire to agricultural cooperatives	Compare APOLLO platform crop yield estimation and agricultural cooperatives' current crop yield estimation services (e.g. how useful do you find APOLLO's crop yield estimation products as a service for your members (scale of 1-5))
2	Yield	Yield Comparison	Yield comparison between the reference plot and the plots that follow APOLLO platform advices (tillage and/or irrigation scheduling)

Table 5- Crop Yield Estimation Service Evaluation Methodology

1.4 Instruments for evaluation

To collect feedback of testing done by the users in the evaluation process, a set of instruments will be installed to enable collecting qualitative and quantitative results of the testing.

In APOLLO project we will use: questionnaires, interviews, forms and logs.

Questionnaires will be provided both online, through APOLLO platform, and offline. General advantages of using questionnaires as evaluation means are that: 1) it is possible to collect data from many users with limited resources; 2) attitudes, knowledge and behaviours are unique to individuals; 3) anonymous responses protects privacy of participants.

Interviews require significantly more amount of resources than questionnaires, but they provide more in-depth information on the user's perceptions, attitudes and experiences. Moreover, the information may be analysed in context of user-related information. Special form of interviews, namely Focus groups, will be also part of the evaluation instruments. Focus group is a moderated discussion between representatives of stakeholders (target user groups) sharing their experiences, opinions and impressions. Both individual interviews and Focus groups will be audio recorded and transcribed.

Forms will be used to keep records on the activities on pilot parcels (e.g. farmer's practice, attitude towards the information/advises from APOLLO services, etc.) and to store the data collected on pilot parcels (e.g. fuel consumption, irrigation dose, yield, crop vigor, etc.).

Logging will be particularly useful for obtaining quantitative information on the system use, including its performance and error occurrence. All users' actions performed during using APOLLO service will be logged. Log files will provide information on: the user’s request, response time and errors. It will enable to discover frequency the users’ use a system feature (or don’t use at all), and problems that occur. Another advantage of the evaluation instrument is that it will automatically collect data from a large number of users.

2 Pilot plan

2.1 Pilot phases

APOLLO pilot will be executed through three different phases: alpha, beta and pilot.

Alpha phase will involve the pilot partner team in the pre-pilot scenario-based testing of usability and technical aspects of the system, The results of this testing will be provided as feedback to improve/correct any issues uncovered before external stakeholders are engaged in the testing.

Beta phase will engage smaller group of stakeholders (farmers and consultants) outside the pilot partners. The participants will be provided with training and assisted to perform beta tests on the live platform following predefined scenarios. Feedback from this stage will be fed back to the development team for the release of the final pilots.

The Pilot phase will ensure that APOLLO services are fully operational. In this phase, a larger group of users will be involved to use APOLLO services in daily real-life scenarios. The goal is to test the solution during a longer period of time and on different crops to ensure variability of meteorological conditions and crops in APOLLO evaluation.

2.1.1 Alpha phase

Context and activities	• Functional and technical testing of the first APOLLO platform version (from T.5.2 Component development and integration) • Participants will use APOLLO platform followingTesting Scenarios
Who is involved	• Testing will be done by pilot partners with small number of alpha users (2-3)
What is evaluated	• Platform technical testing • It will be tested if the functionalities foreseen in platform design have been implemented properly, performance of the system, errors occurrence
Requirements	• APOLLO first prototype (alpha version of the platform) • Data (EO data products exist for test parcels, boundaries of test parcels) • Testing Scenarios designed
Outcome	• Internal reports on pilot activities • D6.2 1st APOLLO Training Material • D6.5 1st Intermediate Evaluation Report
Duration	May-July 2017

Table 6 - Alpha phase implementation plan

This project is co-funded
by the European Union

2.1.2 Beta phase

Context and activities	• First evaluation period • Trials are held in controlled environment: involved end-users are guided by pilot and technical partners • Training and assistance provided to the participants in the testing • Survey (questionnaires and interviews) to collect users' feedback • Analysis of the user's feedback • In-situ data collection (for validation and calibration of EO data products and evaluation of the agricultural services)
Who is involved	• Done by the alpha users (farmers and consultants) engaged by Pilot partners
What is evaluated	• General platform technical testing • Evaluation of the platform • Evaluation of the services: crop-monitoring, yield estimation, irrigation scheduling, tillage scheduling
Requirements	• APOLLO Beta version (improved according to the feedback from alpha phase) • EO data products generation runs operationally • Limited number of participants in testing –alpha users • Instruments for evaluation (questionnaires, interviews..) • In situ data for validation of APOLLO EO products (from soil moisture sensors, field measured LAI, field measured biomass, yield, etc.) • Parcels for evaluation of services • Data for evaluation of APOLLO services (fuel consumption, yield, irrigation dose, …)
Outcome	• Internal reports on pilot activities • D6.3 2nd APOLLO Training Material • D6.5 1st Intermediate Evaluation Report
Duration	July 2017-April 2018

Table 7 – Beta phase implementation plan

This project is co-funded
by the European Union

2.1.3 Pilot phase

Context and activities	• Second evaluation period • APOLLO platform runs operationally in the pilot areas • Pilot users use APOLLO platform and services in daily real-life scenarios • Survey (questionnaires and interviews) to collect users' feedback • Analysis of the user's feedback • In-situ data collection (for validation and calibration of EO data products and evaluation of the agricultural services)
Who is involved	• Additional end-users involved to reach the numbers stated in the DoW
What is evaluated	• General platform testing • Evaluation of the platform • Evaluation of services: crop-monitoring, yield estimation, irrigation scheduling, tillage scheduling •
Requirements	• APOLLO improved beta (improved according to the feedback from beta phase) • EO data products generation runs operationally • Involvement of additional number of end-users • Instruments for evaluation (questionnaires, interviews..) • In situ data for validation of APOLLO EO products (from soil moisture sensors, field measured LAI, field measured biomass, yield, etc.) • Parcels for evaluation of services • Data for evaluation of APOLLO services (fuel consumption, yield, irrigation dose, …)
Outcome	• Internal reports on pilot activities • D6.7 Validation Report
Duration	April – November 2018

Table 8 –Pilot phase implementation plan

2.1.4 Target numbers

To obtain relevant evaluation results, a certain number of end-users (farmers, consultants and cooperatives) to be involved in APOLLO pilot has been defined. Also, trials of APOLLO services will be conducted on a number of pilot parcels. The target numbers according to the DoW are presented in Table 9.

Target numbers	**Greek pilot**	**Serbian pilot**	**Spanish pilot**	**Total**
Number of small farmers participating in the pilots	26	30	11	67
Number of agricultural consultants participating in the pilots	15	6	1	22
Number of agricultural cooperatives participating in the pilots	1	1	1	3
Number of agricultural parcels to be subject of trials	26	30	11	67

Table 9 – Target numbers in APOLLO evaluation

2.2 Training

In order to provide technical support to the users, comprehensive training material will be produced. Quality of the training material can significantly affect user experience and acceptance.

The training material will be composed of both printed and digital multimedia material. Training material will be designed to fit the needs of APOLLO users. It will consist of training manuals (complete set of instructions) and tutorials (set of step-by-step lessons on how to do something). In addition, a set of material which will be explaining all identified benefits of APOLLO services to the users will be created.

The work on creating the training materials will be an iterative process. The first version of the material will be prepared during the beta phase of the pilot. It will be produced in relation with the co-creation process (T.2.3 Co-creation of services) as the alpha users will be consulted. The material will be further improved during the beta and pilot phase according to the feedback received by the users involved in evaluation.

For alpha users involved in alpha and beta pilot phase, it will be organized training workshops. The aim of the workshops is to provide the users knowledge on APOLLO platform and to prepare them to participate in the trials and evaluation.

2.3 In situ data collection

For further calibration of the models designed to generate EO data products (soil moisture, LAI, Chlorophyll content, biomass) within the scope of WP3 and validation of the products, a comprehensive set of in situ data is required. The in situ data will be collected continuously by the APOLLO pilot partners in each of the pilot areas during the pilot. Methodology for in situ data collection is designed and provided to the pilot partners (ANNEX II).

In addition to that, in order to evaluate APOLLO services in terms of benefits to the end users and validate yield estimation and crop stage information, additional data will be collected on the pilot parcels (e.g. fuel consumption, irrigation dose, yield, crop quality indicators).

2.4 Roles, responsibilities and communication

All project partners are involved in APOLLO pilot execution. To assure smooth pilot running, it is necessary to define roles and responsibilities of the partners and communication channels.

Technical partners (UBFCE, DRAXIS, AUA, Starlab, TUW, EVF) will: a) insure that technical requirements are fulfilled in each of the pilot phases (i.e. platform running operationally, data is available), b) design evaluation material (i.e. questionnaires, interviews), c) validate EO data products using in situ data, d) analyze information collected during evaluation process, e) design training material, f) provide training and assistance to the pilot partners.

Pilot partners (ACP, AgriSat, UPOR) will: a) recruit the users that will participate in evaluation, b) determine parcels that will be used for evaluation of APOLLO services, c)provide training and assistance to the users that participate in the pilot, d) collect feedback from the users (direct interviews, informal feedback), e)collect in situ data for calibration and validation of EO data products and evaluation of agricultural services, f) participate in evaluation along with technical partners.

Leading partner in WP6 (UBFCE) will coordinate the activities.

Communication of information from the pilot will be organized both within the scope of the pilot execution (WP6) but also with external tasks dependent on the information (T.5.3, Modification based on pilot feedback, T.7.1 Exploitation) (Figure 6).

Collecting users' feedback through questionnaires and interviews will be performedby using free web services (e.g. Google Forms). Results of data analysis and evaluation will be recorded and communicated through regular internal reports and official deliverables.

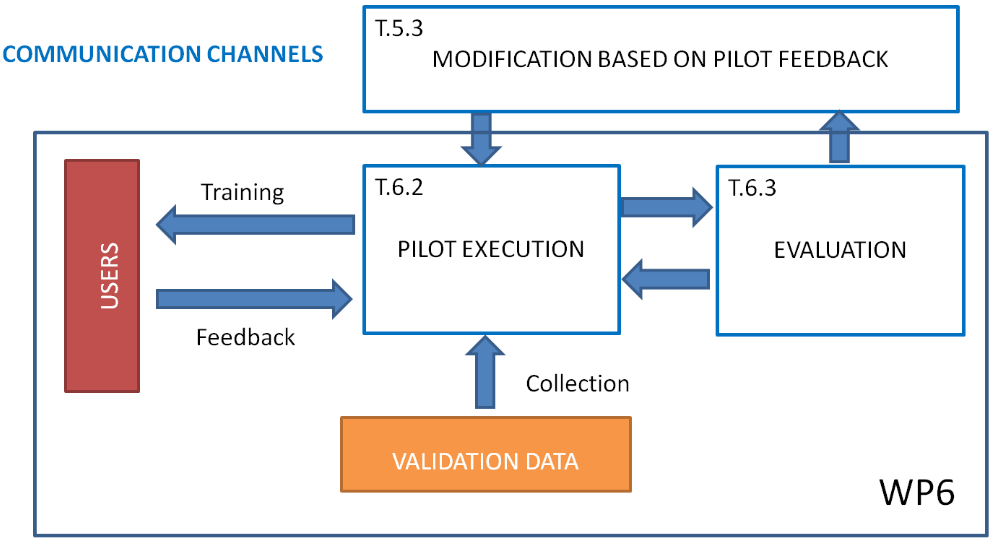


Figure 6- Communication during APOLLO pilot

This project is co-funded
by the European Union

3 Ethical and legal issues

One of the tasks of the methodology is to identify any possible ethical issue that can arise during APOLLO evaluation. The testing that will take place within the scope of evaluation process will involve human subjects representing the final users of the APOLLO services. To define main ethical issues that can rise as the result, we should start with the question:

- Will the people involved in the testing be exposed to any harm?

According to Frankel and Siang (1999), "ethical and legal framework for protecting human subjects rests on the principles of autonomy, beneficence, and justice. The first principle, autonomy, requires that subjects be treated with respect as autonomous agents and affirms that those persons with diminished autonomy are entitled to special protection. In practice, this principle is reflected in the process of informed consent, in which the risks and benefits of the research are disclosed to the subject. The second principle, beneficence, involves maximizing possible benefits and good for the subject, while minimizing the amount of possible harm and risks resulting from the research. Since the fruits of knowledge can come at a cost to those participating in research, the last principle, justice, seeks a fair distribution of the burdens and benefits associated with research, so that certain individuals or groups do not bear disproportionate risks while others reap the benefits."

Regulation (EU) No 1291/2013 of the European parliament and of the Council brings general outlines of the ethical framework to be applied in the H2020 research:

"(29) Research and innovation activities supported by Horizon2020 should respect fundamental ethical principles. The opinions of the European Group on Ethics in Science and New Technologies should be taken into account. Article 13 TFEU should also be taken into account in research activities, and the use of animals in research and testing should be reduced, with a view ultimately to replacing their use. All activities should be carried out ensuring a high level of human health protection in accordance with Article 168 TFEU."

"Article 6

Ethical principles

1. All the research and innovation activities carried out under Horizon 2020 shall comply with ethical principles and relevant national, Union and international legislation, including the Charter of Fundamental Rights of the European Union and the European Convention on Human Rights and its Supplementary Protocols.

…"

During the evaluation of APOLLO platform, end-users (farmers and consultants) will be involved in the testing of APOLLO services. The testing also include following advises and using information provided by APOLLO services in farmer's usual agricultural practice. The feedback from the users and various data on the crops will be collected, processed and analyzed.

In order to respect the above mentioned ethical principles, APOLLO partners carrying out the evaluation should:

- Inform farmers involved in evaluation on the research protocol, risks they could face (e.g. damage to the crop if information from the service is wrong) and research benefits;

- Obtain consent from the farmers and consultants participating in the pilots;
- Obtain consent from the farmers on collecting in situ data from their fields;
- Inform farmers/consultants that they can withdraw from research at any time without suffering negative consequences;
- Ensure anonymous participation of research subjects;
- Provide necessary help and support to the interested research subjects;

4 Risks and mitigation plans

The following risks related to successful pilot execution has been identified (Table):

RISKS	MITIGATION
Low number of users interested to participate in pilot activities	Pilot partners with the support of technical partners will work closer with the users. The focus will be on the benefits of participating in the project and exclusive access to the services in the early stage. Also, more intensive dissemination activities will be performed in the pilot phase.
Farmers don't give consent to collect in situ data on their fields	Pilot partners will carefully approach to each of the farmers involved with detailed explanation of the benefits of participating in the project (that should motivate the farmers), minimal damage to the crops (in case an destructive method of in situ data collection is applied) and data protection policy
Pilot fields not representative for evaluation of the services (e.g. due to an extreme event)	More alternative pilot parcels will be involved in evaluation
Difficulties in platform running during the pilot phase	Communication protocol will be established between the users, pilot partners and APOLLO developing team aimed at reporting any technical problems that prevent correct running of the pilots.
The data and information provided through APOLLO services is insufficiently accurate	Further calibration of the models for generation of APOLLO products will be performed.
Insufficient in situ data collected from pilot areas	In situ data will be collected from any available sources (e.g. other projects, national and international networks and organizations, etc.)

Table 10– Risks and mitigation

This project is co-funded
by the European Union

5 Conclusions

This deliverable presents methodology for evaluation of the APOLLO platform during pilot part of the project as well as the plan for pilot execution. The methodology follows state-of-the-art theoretical framework of the User Centered Design. As one of the main objectives of APOLLO project is to deliver commercial solution, the users have been placed in the focus during the development process. The criteria for evaluation will thus be: user experience, user acceptance and measurable benefits to the users.

The pilot plan is designed to ensure gradual improvement of the APOLLO platform. In the first phase the focus will be on functional and performance testing. In the second (beta) phase, a limited number of alpha users will test the services by integrating them in their agricultural practice. In the third and more mature (pilot) phase larger number of users will be invited to use the platform in daily real-life scenarios. The feedback will be used in constant improving and optimization of the platform.

This document is also addressing other aspects of the APOLLO pilot such as potential ethical and legal issues and other risks and mitigation solutions. Furthermore, the directions for preparation and design of training material is provided.

6 References

Ajzen, I., Fishbein, M., 1980, Understanding attitudes and predicting social behaviour, Englewood Cliffs, NJ: Prentice-Hall.

Broner, I., 2005, Irrigation Scheduling. Crop Series, Irrigation. Fact Sheet No. 4.708. Colorado State University Extension.

Davis, F. D., 1993, User acceptance of information technology: System characteristics, user perceptions and behavioral impacts, International Journal Man-Machine Studies, 38(3), 475-487.

http://dx.doi.org/10.1006/imms.1993.1022

Dexter, A.R., Czyz, E.A., Birkas, M., Diaz-Pereira, E., Dumitru, E., Enache, R., Fleige, H., Horn, R., Rajkaj, K., de la Rosa, D., and Simota, C., 2005, SIDASS project Part 3. The optimum and the range of water content for tillage – further developments. Soil and Tillage Research, 82:29-37.

Dillon, A. and Morris, M., 1996, User acceptance of new information technology: theories and models. In M. Williams (ed.), *Annual Review of Information Science and Technology*, Vol. 31, Medford NJ: Information Today, 3-32.

Hassanli, A.M., Ebrahimizadeh, M.A., and Beecham, S., 2009, The effects of irrigation methods with effluent and irrigation scheduling on water use efficience and corn yields in an arid region. Agricultural Water Management, 96(1):93-99.

Nichols, C., 1997, Satellite Imagery: An Advanced Diagnostic Tool for Crop Scouts using GPS. Better Crops, 81:22-24.

Nielson, J., 2012, Usability 101: Introduction to Usability, Retrieved from http://www.nngroup.com/articles/usability-101-introduction-to-usability/

Rasimah, C. M. Y., Halimah, B.Z., Azlina, A., 2011, Evaluation of user acceptance of mixed reality technology, Australasian Journal of Educational Technology, 27 (Special issue, 8), 1369-1387

Servadio, P., Bergonzoli, S., and Beni C., 2016, Soil Tillage Systems and Wheat Yield under Climate Change Scenarios. Agronomy, 6:43. doi:10.3390/agronomy6030043

Zotarelli, L., Scholberg, J.M., Dukes, M.D., Munoz0Carpena, R., and Icerman, J., 2009, Tomato yield, biomass accumulation, root distribution and irrigation water use efficiency on a sandy soil, as affected by nitrogen rate and irrigation scheduling. Agricultural Water Management, 96(1):23-34.

Annex I: Instructions for in situ data collection

APOLLO CROPS	PHENOLOGICAL STAGES
WHEAT	**Spain**: sowing (dec-jan), emergence (jan), tillering (mar), stem elongation (apr), flowering (may), ripening (jun), harvest (jul) **Serbia:** sowing (oct-nov), emergence (nov), tillering (mar), stem elongation (mar-apr), flowering (may), ripening (jun), harvest (jun-jul) **Greece:** sowing (nov), emergence (nov), tillering (jan), flowering (apr), ripening (may), harvest (june)
BARLEY	**Serbia:** sowing (oct-nov), emergence (nov), tillering (mar), stem elongation (mar-apr), flowering (may), ripening (jun), harvest (jun-jul) 6.1.1
COTTON	**Greece:** sowing (April), emergence (April), flowering (July), ripening (September), harvest (September – October)
SOYA	**Serbia:** sowing: April, emergence – 10 – 20 days after the sowing , intensive growth (stem elongation???) - May-June , flowering – July, Ripening – September, Harvest – end of September - October 6.1.2
SUGAR BEET	**Serbia:** sowing: March-April, emergence – 10 – 20 days after the sowing , intensive growth (stem elongation) - May-June , flowering – none, Ripening – end of August-October, Harvest –September - October
MAIZE	**Spain:** - sowing (mar-may), emergence (apr-jun), flowering (jul), ripening (ago-sep), harvest (oct-nov) **Serbia:** sowing: April, emergence – 10 – 20 days after the sowing , intensive growth (stem elongation) - May-June , flowering – July, Ripening – September, Harvest – end of September – October 6.1.3

SUNFLOWER	**Serbia:** sowing: March- April, emergence – 10 – 20 days after the sowing , intensive growth (stem elongation) - May-June , flowering – July, Ripening – end of August, Harvest – end of August -September
CHINESE GARLIC	**Spain:** sowing (sep-oct), bulbing (mar), harvest (jun)
PURPLE GARLIC	**Spain:** sowing (dec-jan), bulbing (apr), harvest (jul)

1. IN SITU DATA COLLECTION DINAMICS AND VOLUME

This section defines how many sample points and how often should measurements take place per crop type per pilot partner is required

LAI - is measured only when at least 50% of the leaves are green (no need for LAI data collection during senescence)

Chlorophyll content - is measured only when at least 50% of the leaves are green (no need for Chl data collection during senescence)

BIOMASS - at least 4 measurements during crop season

Sample point - is a place on a field where the IN SITU data is collected. Sample points doesn't have to be fixed during campaign (i.e. they can change locations).

Data collection plans for each pilot are presented in the following tables.

SPAIN

Crop	**Number of measurements**								
No. of sampling points	**Febr**	**March**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
WHEAT **2 sample points**		2 (once every 2 weeks)	4 (once every week)	4 (once every week)	2 (once every 2 weeks)	1 (once first week)			
	Biomass measurements according to the current practice								

MAIZE* **2 sample points**				4 (once every week)	4 (once every week)	4 (once every week)	2 (1st and 3rd week)		
	Biomass measurements according to the current practice								
CHINESE GARLIC **2 sample points**	1 (once end of month)	2 (once every 2 weeks)	4 (once every week)	4 (once every week)					
	Biomass measurements according to the current practice								
PURPLE GARLIC **2 sample points**		1 (once end of month)	2 (once every 2 weeks)	4 (once every week)	4 (once every week)				
	Biomass measurements according to the current practice								

* DEPENDS WHEN IS SOWING, IN SPAIN IT CAN BE FROM MARCH TO MAY

SERBIA

Crop	**Number of measurements**								
No. of sampling points	**Febr**	**March**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
WHEAT **2 sample points**		2 (once every 2 weeks)	4 (once every week)	4 (once every week)	2 (1st and 3rd week)	1 (once first week)			
BARLEY **2 sample points**		2 (once every 2 weeks	4 (once every week)	4 (once every week)	2 (1st and 3rd week)	1 (once first week)			
MAIZE **2 sample points**				4 (once every week)	4 (once every week)	4 (once every week)	2 (1st and 3rd week)	1 (once first week)	

SOYA **2 sample points**				4 (once every week)	4 (once every week)	4 (once every week)	2 (once every 2 weeks)	2 (once every 2 weeks)	
SUNFLOWER **2 sample points**				4 (once every week)	4 (once every week)	2 (first two weeks)	2 (once every 2 weeks)		
SUGAR BEET **2 sample points**				4 (once every week)	4 (once every week)	4 (once every week)	2 (once every 2 weeks)	2 (once every 2 weeks)	

GREECE

Crop	**Number of measurements**								
No. of sampling points	**Febr**	**March**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
WHEAT **3 sample points**	2 (once every 2 weeks)	2 (once every 2 weeks)	4 (once every week)	2 (once every 2 weeks)	2 (once every 2 weeks)				
COTTON **4 sample points**			1 (once end of month)	4 (once every week)	4 (once every week)	4 (once every week)	4 (once every week)	2 (once every 2 weeks)	

2. METHODOLOGY

The data collected on the sample points will be recorded in the following Data Collection Tables (DCT):

6.1.4

For Spain: https://drive.google.com/open?id=1F1qDytxPUyeevTwGj3lWUSLuk0yb7f-

This project is co-funded by the European Union

6Bd4h46jQwok

6.1.5

For Greece: https://drive.google.com/open?id=1EZX8PRzkDsia0RuDe51WSd7cHPuDmmiD4PB0jGTYszQ

6.1.6

For Serbia: https://drive.google.com/open?id=13VR25FYtH92yN4KoZIbJTfvEhfid-h902HK-j0uJWwE

6.1.7

Each sheet in the document is related to one crop type.

GENERAL RULES

6.1.8

- Sample point should be at least 30m from the field boundaries.

- Crop should be relatively homogeneous at least 10m around sample point

- When a sample point is identified, collect GPS coordinates

- Fill-in the fields related to general data within the data collection table (DCT): Sample point identification number, GPS coordinates, date, crop type, BBCH code, Comment (if any)

- **Identify at least 3 average plants within the 10m circle around the sampling point**

- Measure Chlorophyll content on those plants using atLEAF+ device and fill in the related field (insert the average value) in the data collection table (DCT). Take measurements from different leaves and calculate the average value.

- Cut the plants at ground level and put in a paper/plastic bag. Label the bag to be able to link it to the sample point

- Measure LAI and biomass in the laboratory conditions and fill in the related fields in the data collection table (DCT)

6.1.9

(green) LAI CALCULATION

1. Make a clean white square with 1x1m dimensions (e.g. from better paper, plastic,…).

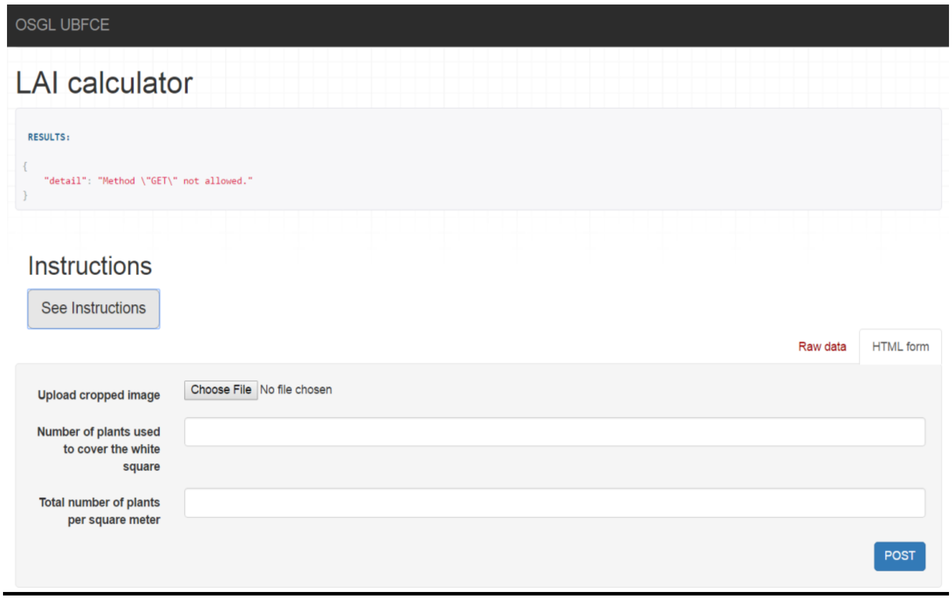
2. Cover it with the leaves (**GREEN ONLY**) taken from a sample point. The leaves should not overlap.

3. Take an orthogonal photo of the 1x1m white square background covered with the leaves. Set the camera so the edges of the photo are parallel (closely) to the borders of the white square.

4. Crop the image to the borders of the white square. You can do it in the online image editor: http://www169.lunapic.com/editor/

5. Use the OSGL LAI calculator to get the LAI value for the sample point: http://osgl.grf.bg.ac.rs/lai

Upload the cropped image. Insert the number of plants used to cover the white square. Insert the total number of plants per square meter on the field. Press POST.



```
RESULTS:

{
    "detail": "Method \"GET\" not allowed."
}
```

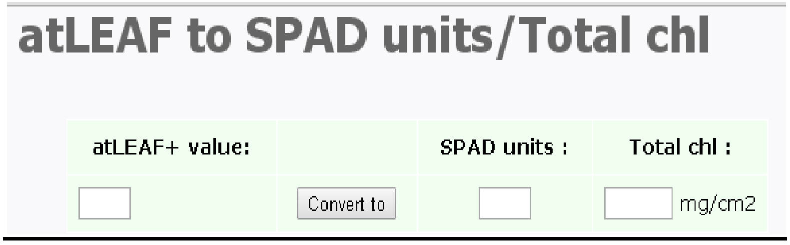
Upload cropped image: No file chosen

Number of plants used to cover the white square:

Total number of plants per square meter:

CHLOROPHYLL CONTENT CALCULATION

Use the atLEAF online service to convert atLEAF values into Total Chl (mg/cm2):http://www.atleaf.com/SPAD.aspx



atLEAF to SPAD units/Total chl

atLEAF+ value:

SPAD units :

Total chl : mg/cm2

TOTAL BIOMASS MEASUREMENT

1. Dry slowly the plants (leaves, stems and grain) - oven-drying at 60°
2. Measure the weight of dry plants from one sample point
3. Calculate the Average Plant Weight (g)=measured weight (g)/number of plants
4. Calculate Biomass (g/m2)= Average Plant Weight (g) x number of plants in 1m2

END OF DOCUMENT