Deliverable D200.4

Smart Farming: Final Assessment Report

WP 200

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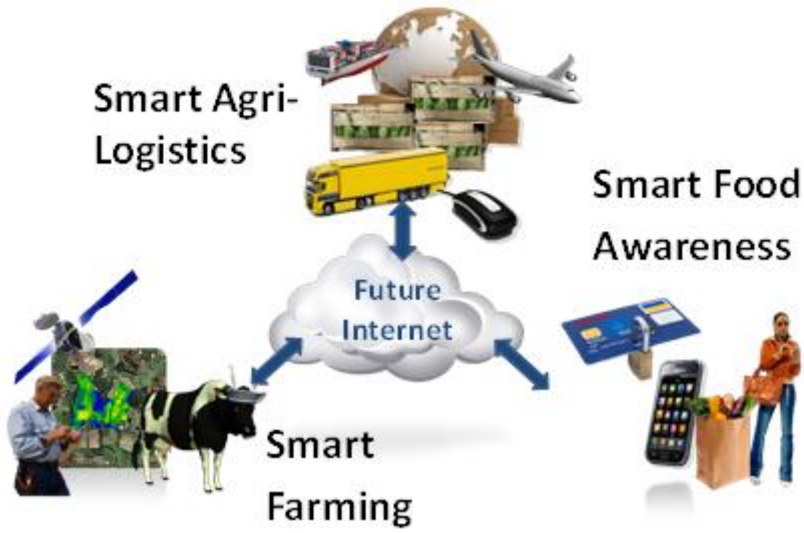
The SmartAgriFood Project

The SmartAgriFood project is funded in the scope of the Future Internet Public Private Partnership Programme (FI-PPP), as part of the 7th Framework Programme of the European Commission. The key objective is to elaborate requirements that shall be fulfilled by a "Future Internet" to drastically improve the production and delivery of safe & healthy food.

Project Summary

SmartAgriFood aims to boost application & use of Future Internet ICTs in agri-food sector by:

- Identifying and describing technical, functional and non-functional Future Internet specifications for experimentation in smart agri-food production as a whole system and in particular for smart farming, smart agri-logistics & smart food awareness,
- Identifying and developing smart agri-food-specific capabilities and conceptual prototypes, demonstrating critical technological solutions including the feasibility to further develop them in large scale experimentation and validation,
- Identifying and describing existing experimentation structures and start user community building, resulting in an implementation plan for the next phase in the framework of the FI PPP programme.



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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Change History

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001	Creation of the document	2012-06-11
006	First complete version	2012-12-19
1_0	Reviewed by partners	2013-01-29
1_1	Adopted reviewer's recommendations	2013-04-16

Document Summary

This document delivers an overall assessment of the conceptual prototypes of the two Smart-Farming sub-use cases "SmartGreenhouse" and "SmartSpraying

The end user validation has been done separately for the SmartSpraying and the SmartGreenhouse pilot. The results of the final end user evaluation are described in detail in this document. The end-users did see benefits of the proposed service and spraying concepts with regard to increased effectiveness of work and reduction of workload, but in particular they found chances to develop the work, create learning possibilities and improve competences.

The SmartGreenhouse pilot has been mainly evaluated in Greece, both in discussion panels and using questionnaires. A vast majority of respondents regard the pilot as useful or very useful. A number of additional functionalities are suggested.

In order to evaluate the overall outcome of the SmartFarming sub use cases, their economic and environmental benefits, social aspects, and the technical evolution path were evaluated. In order to quantify the economic benefit of the FutureInternet technology to the farmer, a business case was analysed. This analysis shows that even a minor decrease in costs in parallel with a moderate increase in earnings which is made possible by an improved response to the market requirements causes a significant improvement of the economic outcome of the farm. Considering the environmental aspects, SmartFarming can benefit by improving irrigation, site-specific pesticide application and lower energy consumption. These aspects are described in further detail. The examination of the social aspects shows that the highest benefit is seen in the possibility to learn and to develop new competencies for farmers. The technical evolution prospects of the pilots is analyzed regarding extensibility, flexibility, scalability (how big is big data), and portability.

In the last section, the functionalities of both pilots are linked to the responsible providers. Finally, the future development plan is discussed. It would be very important to involve the policy, government, and regulatory aspects into the development work.

Abbreviations

CAGR	Compound annual growth rate
CAPEX	Capital expenditure
COGS	Cost of goods sold
D	Deliverable
dt	1 tenth of a ton
EBIT	Earnings before interest and tax
EBITDA	Earnings before interest, tax, depreciation & amortization
FI	Future Internet
FI-PPP	Future Internet Public Private Partnership
GM	Gross margin
ICT	Information and Communication Technology
IRR	Internal rate of return
MVA	Market value added
NOPAT	Net operating profit after tax
NPV	Net present value
OPEX	Operational expenditure
P&L	Profit & Loss
TCO	Total cost of ownership
WACC	Weighted average capital cost

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Executive summary

One of the goals of WP200 “Smart Farming” was to develop a small scale prototype pilot system to demonstrate the key features of the smart farming use case. For two sub-use cases “Smart-Greenhouse” and “SmartSpraying”, conceptual prototypes were developed. Along the realisation of the conceptual prototypes and their overall assessment, the sub-use case related functionalities were further evaluated with end-users and documented. This document delivers an overall assessment of these two conceptual prototypes. The target audience are the project partners within the FutureInternet project and decision makers, but also end users such as farmers and developers of agricultural software who want to be aware of future trends.

The end user validation has been done separately for the SmartSpraying and the SmartGreenhouse pilot. The first five steps of the end user evaluations of the SmartSpraying concept confirmed its potential and provided the basis for further development of the pilot. The results of the final end user evaluation are described in detail in this document. The end-users did see benefits of the proposed service and spraying concepts with regard to increased effectiveness of work and reduction of workload, but in particular they found chances to develop the work, create learning possibilities and improve competences.

The SmartGreenhouse pilot has been mainly evaluated in Greece, both in discussion panels and using questionnaires. A vast majority of respondents regard the pilot as useful or very useful. A number of additional functionalities are suggested, e.g. Extension of the pilot for the outdoor cultivation.

In order to evaluate the overall outcome of the SmartFarming sub use cases, their economic and environmental benefits, social aspects, and the technical evolution path were evaluated. In order to quantify the economic benefit of the FutureInternet technology to the farmer, a business case was analysed. This analysis shows that even a minor decrease in costs in parallel with a moderate increase in earnings which is made possible by an improved response to the market requirements causes a significant improvement of the economic outcome of the farm. Considering the environmental aspects, SmartFarming can benefit by improving irrigation, site-specific pesticide application and lower energy consumption. These aspects are described in further detail. The examination of the social aspects shows that the highest benefit is seen in the possibility to learn and to develop new competencies for farmers. The technical evolution prospects of the pilots is analyzed regarding extensibility, flexibility, scalability (how big is big data), and portability. The pilots are based on open and widely used standards and use the FI-WARE’s new technology, which makes them extensible, flexible, scalable and portable.

In the last section, the functionalities of both pilots are linked to the responsible providers. Finally, the future development plan is discussed. It would be very important to involve the policy, government, and regulatory aspects into the development work.

1 Introduction

This document delivers an overall assessment of the conceptual prototypes of the two SmartFarming sub-use cases “SmartGreenhouse” and “SmartSpraying”. Special emphasis is put on the impact for end-users. The sub-use case related functionalities were further evaluated with end-users and documented.

The target audience are the project partners within the FutureInternet project and decision makers, but also end users such as farmers and developers of agricultural software who want to be aware of future trends. A major part of the results provided in this document were obtained by user evaluation. Another important source is a benchmarking study. Last not least relevant input was provided by the developers of the pilot application, which was further investigated in desktop research.

The main challenge of today’s agrifood sector is to meet the increasing food demand and at the same time reduce the ecological footprint of food production. The agrifood industry has also to provide more transparency to allow a better feedback on how the political, economical, social and health requirements are met. These targets can only be reached by a knowledge driven industry with ICT as a key factor. This document analyses how the SmartFarming sub-use cases can contribute to meet the challenges of future agri-food production.

The results of the validation of the two pilots with end-users are presented in 2. The following chapter evaluates the economic, environmental and social impact of the SmartFarming use case. 3.2. analyses how the pilots can contribute to a more efficient use of resources.

Some considerations can only be given as an indication or potential of what is to be expected. Definitive numbers require actually implementing and deploying the pilots on a larger scale.

As described in the section 3.4.1 the software architecture in SmartFarming pilots follow SOA paradigm. Both pilots consist of a set of un-associated, loose coupled services that are published as RESTful Web APIs. The SmartFarming pilot specifications presented in the deliverables 200.3 and 500.5.2 give comprehensive easy to follow top-to-bottom view to the pilots. The purpose and the functionality of each module are presented as stories, self-explanatory tables, class diagrams and data flow diagrams. On the top of these the RESTful Web API descriptions describe the publicly available interfaces for third party service message exchange and communication. Following the specifications the underlying functionality of the software modules can be implemented using any programming language that supports REST binding. The main focus is on standards and protocols in message exchange between interfaces.

The existing legacy systems can be connected to the pilot systems by

- encapsulating them using REST architecture
- using ESB (enterprise service bus) technology
- using direct connectors when applicable and the only alternative

When it comes to embedded sensors the best way to connect them is to use Internet of Things (IoT) Services Enablement encapsulation as described in related FI-WARE chapter.

This document thus provides the results of the user evaluation and evaluates the technical perspective, but also the overall impact of the SmartFarming pilots.

2 Validation Results

2.1 User evaluation of the pilots in Finland and Greece

In this section a report is given of the end user validations accomplished within WP200 devoted to develop Future Internet based smart farming technology. The technology development took place in developing two pilots Smart Spraying and Smart Greenhouse. These pilots draw on same technological bases as has been described in the D200.2 and in the forthcoming D200.3. Both pilots have been designed from a usage-driven perspective. This means that end-users' needs in greenhouse and arable farming activities were identified and user requirements were formulated as central design goals. Recurrent design workshops and repeated end-user evaluations during the entire development process were also accomplished. The process of a usage-driven design and evaluation process was conceptualised by a model that was labelled V7 model (see D.200.1). The model defines seven steps via which research and design efforts are combined to deliver a gradually maturing design output. These steps portray two types of efforts, i.e., expert-based design tasks and different design and evaluation – oriented interactions with end-users. In the sequence of steps these two types of tasks alternate systematically (see Figure 1).

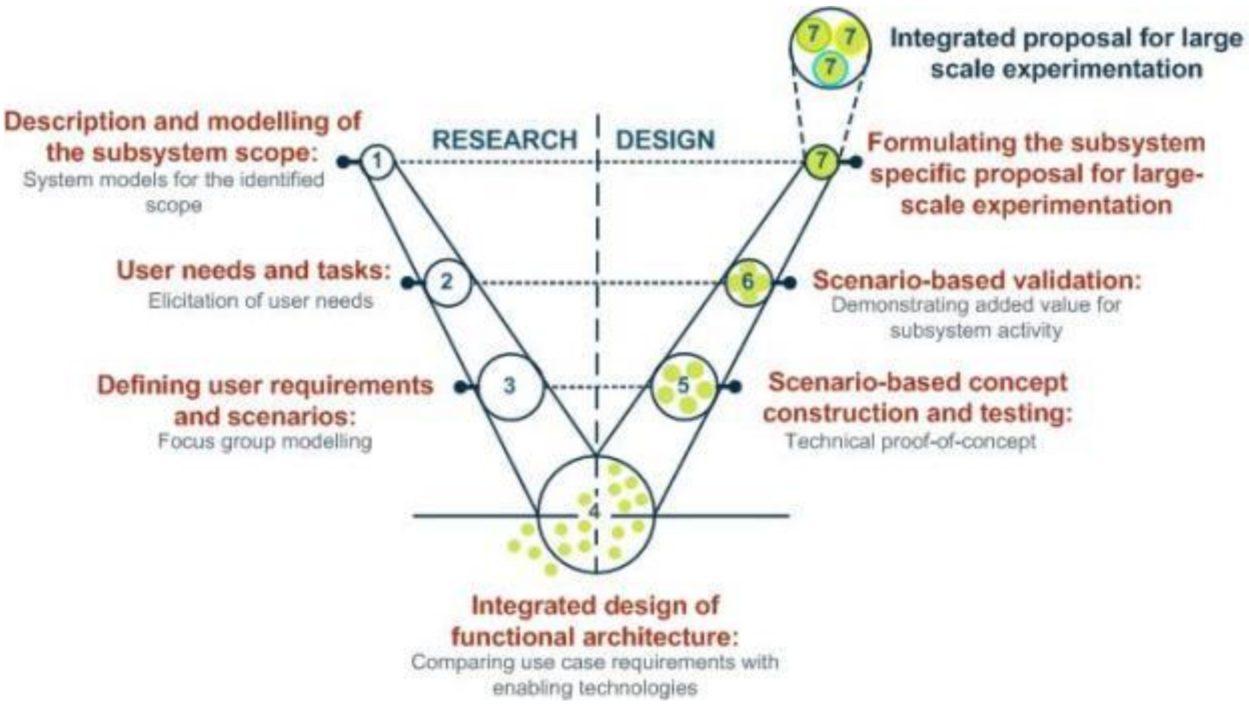


Figure 1: The usage-driven design and evaluation model, the V7 model, used in the WP200

2.1.1 Intermediate evaluation results of Smart spraying (Finland)

In this and the following section 2.1.2 the end-user validation of the Smart Spraying System will be presented. The Smart Spraying System design and development was accomplished in Finland by the joint effort of MTT and VTT. MTT was responsible for the farming domain expertise and for the technical design of concept, whereas VTT was responsible for the end-user validation.

Following the V7 model the first 5 validation steps were accomplished by May 2012 and reported extensively in D200.2. A summary of the intermediate results is given below.

Step 1: System models for the smart farming as part of the IP-based food chain

The usage-driven design and evaluation the Smart spraying pilot concept was first put into the context of the entire food chain. A model was developed that demonstrates how the actors of all the studied three food chain processes (farming, logistics, and retail activity) must take into account the global food chain challenges, i.e. food safety, environment, ethical issues and cultural preferences. The consideration of the global challenges becomes evident in the decisions taken when accomplishing each of the main activities of the chain; farming, logistics and retail. Each of the three activities would have to optimize between specific goals and define the optimisation criteria.

What comes to the Smart farming (spraying) the business models were tentatively defined to identify the basis of the farmers' decision making while optimising between goals. An initial list of business goals was identified. In the following those values that were identified by the end-users to have great value are indicated:

- Avoid possible crop damages and machine damages
- Produce more qualitative products by less pesticides
- Decrease the cost of investment effortlessly
- Be provided with technical support immediately
- Link easily with other stakeholders
- Better link with government and certification authorities
- Reduce tractor down-times and increase maintenance and repair cycles

The connection of these generic business values to decision making in smart spraying situations was also studied with the aim to understand the information requirements of the FI-based services. It was found that the smart farming work process focuses on optimizing between the following goals:

- Safety of the product (food safety): Pesticide residue relates to the consideration of the safety of the end product. In order to monitor this optimization goal the actor needs to pay attention to his/her pesticide usage and that the usage fulfils the set rules and norms.
- Environmental values: Wind drift is one of the most important goals of optimisation that relates to accounting environmental values. The criterion is observing the wind direction and velocity while spraying.
- Environmental values are also portrayed when considering the carbon footprint goal. The criterion to observe by the actors is that fuel consumption is kept under set carbon dioxide limits.

Step 2: End-user needs

In this step end user needs were conceptualised on the basis of interviews and focus groups which were carried out in five countries within Work Package 700 of SmartAgriFood project. Participants expressed limitations of present farming situation with currently available technical equipment and also brought up their needs and expectations from the future technology:

Information and data: limitations and expectations:

The information available on the internet presently was felt limited, it is not appropriately specific or detailed or the databases are not available and/or expensive. In many cases most of the available information is inaccurate and unreliable.

- The most important need is sufficient information (weather and ambient conditions, soil conditions etc.) collected into a connected database.
- Getting the right information or sharing the information and knowledge with the neighboring farmers – via a shared infrastructure - was found important.
- There are not appropriate sensors or the existing sensors are inaccurate. This is particularly true for the GPS systems used.
- Sensor information could be useful. Monitoring the health status of the crop and animals or weather and ambient conditions continuously can be ensured by using a large amount of sensors. Sensors to measure temperature/humidity are also important for the farmer for identifying if crops are degrading or the likelihood of pest or disease development.
- Using a network of sensors or at least connecting more sensors to each other is also a basic criterion for a well-functioning, improved system.
- An advisory system can provide some sort of a market price e.g. for specific plants on a specific area, thus some investment decisions can be made on that basis.
- Communication of machinery with the farm management information system, where each machine and each tractor should be able to communicate with the farm, and the high data transmission rates could ensure that data exchange never would cause delays in the field work.

Communication and data transfer: Limitations and expectations:

- The communication within a farm or between the partners is too slow.
- Large sized files, photos and videos cannot be transmitted.
- In many regions there is not complete network coverage (e.g. the web is not accessible) or the internet services are hobbling because of network congestion.

Applications and devices: Limitations and expectations

- The current devices and files cannot be combined with each other and are not standardized. The applications are segregated and are not used, or cannot be organized into a system.
- There are no appropriate applications or the applications and solutions are too expensive, in addition the use of these applications is often very complicated.
- Users usually have limited information about the new technologies and cannot imagine and interpret the operation and the exploitation of the envisaged functions of the FI.
- For achieving the availability of the future internet the compatibility of the different applied devices, programs and systems or the integration of systems instead of different connected applications should be ensured and there is a need for longer range in data exchange/transfer and in communication.

Security, good availability and quality of information: Limitations and expectations

- Ensuring of safety and security of data and information is a specifically essential element of the Future Internet. Most of the users are worried about the unauthorized use of their data and they require that the expected systems and applications should be safe.

- Availability of databases should be regulated and controlled to guarantee the data security and protection.
- Prioritization of information is important. Selection of the relevant, important and reliable information and proving its verity is equally important than to collect and distribute more and more information.
- Services, the equipment, the devices, etc. should be available everywhere and they can operate their business processes remotely from anywhere and it is necessary that the applications and devices should be integrated and standardized.

It appeared that the users have limited information about the new technologies and FI functions. Also there is a need to draw attention to the importance of explaining the potential opportunities, functions and applications of the FI for the users in non-ICT, user-friendly style. There is a need to make repeated efforts on clear explanation of the new opportunities and functions of Future Internet in a user friendly style.

Step 3: User requirements and use cases

In total 29 mini use cases were identified for the smart farming domain (see D200.1, Appendix A). These use cases were summarised to form architectural requirements and further grouped into functional blocks relevant to the system architecture. The results are further utilised in the development of the specific pilots.

Step 4: Integrated design of the architecture

The first result of this design step is the set of conceptual models of the Smart Spraying system from the usage point of view. Two types of conceptual models were constructed.

The first model was an overall model that makes explicit the connection of the Smart Spraying Pilot to the overall objectives of the food chain. The second model provided a conceptualisation of the core-task demands of smart spraying, and the innovative technology concept divided into functional requirements and innovative solutions. End user evaluations concerning the main innovative solutions of the model were received as follows.

General

- The Smart spraying project was found challenging because there is already existing infrastructure in farming field and one big concern is how that can be connected to the new internet supported infrastructure.
- Adopting this kind of future internet supported farming system demands a change also in the farming/working culture.
- The farmers did not think it would be impossible to mark their own information in the cloud appropriately. Defined ownership of information is essential if one is going to sell and develop new business around it.

Solution 1: Tailored services: Integration of external and internal data for tailored spraying services

- Potential is seen when local (e.g. micro level) information can be easily connected with the data provided by other service providers/ sources and in this way made even more accurate and suitable for own purposes.
- Micro weather information service would be useful for local farmers and could potentially create some new business. It is important to know if it is going to rain within two hour or eight hours.
- Main challenge is that different equipment does not communicate with each other. All systems so far have been closed.
- It would be useful if it would be possible to collect the weather information from many local actors and aggregate that as an "own weather" service. This could then be used for optimizing own farming process. The farmer could also develop refined services for sale for other purposes (e.g. local holiday weather). All bigger service providers base their weather information on Foreca's weather forecast but in the micro weather there is the real potential. Basically you could even go underground and get soil information.
- The idea that the farmer can choose or adapt the services for his/her own use is really good. That created a possibility to modify and alter the services according to own needs.

Solution 2 Recommendations: Aggregated recommendations for decision making in spraying tasks

- Many useful recommendations for spraying task was envisioned and all of them were emphasizing that most value can be created if the spraying is done only when there is a real need for it.
- Already now, local weather information is collected from local small scale weather stations. But, there is no added value in collecting the same information that can be already provided by the national weather organizations (e.g. through radar pictures). The potential is on feeding the macro weather with micro weather information. In this way we could provide flora specific operation recommendations.
- For example, the disease alarms are mostly based on macro weather but in fact it is the micro climate inside the growth that determines that real risk.
- The Meteorological institute has already radar pictures that are sensitive enough to detect swarm of insect but this information is actually not used for that purpose. So the data already exists and maybe through this future internet it could be made usable/available for farmers.
- Precise weather information is useful for optimizing for example the order of spraying in larger areas, e.g. by spraying contractor in customers fields.
- The value of this system is that you go for spraying only when it is needed.

Solution 3 Context aware work support: Timely service offering and information presentation according to spraying process

- It could be a big item of expenditure if it could be possible to get better information about the real need for spraying or support for optimizing the driving order.
- The reliability of the internet connectivity in farm areas can still be a problem for applying all these services. Few years ago it was sometimes problematic even to get mobile calls through because the bad network covers.
- Especially the restrictions of the internet connection come true when there is a need for handling larger data file (e.g. video feeds).

- This system would be really good for contractors. The contractor would have easy access to his/her customers' field information. The contractor also could more easily discuss about the need and timing for spraying if there would be background support from the future internet services.

Solution 4 Synthetic feedback: Reporting by documenting connections between conditions, actions and outcomes

- One general goal that can be seen in the future farming business is the demand for increasing production efficiency and the other is reducing the environmental effect.
- Agricultural E-learning through internet is the future. Farmers do not have time for long education/ training periods. They want to study remotely so that they can at the same time manage their farm activities.
- It would also be useful if the farmer could choose/ select the parts of the curriculum that are relevant for him/her

Solution 5 Food chain communication: Established communication channels with different stakeholders

- The possibility for genuine two way communication within the food chain can bring added value for farming business.
- It would bring added value for the consumer if he/she could get the precise information concerning different products' food chain history in the grocery store. In this way also part of the farming information could be communicated all the way to the consumer.
- It can also work other way around. For example, some consumer groups might want some specific kind of food, e.g. because of food allergies, or other personal reasons. Farmer could use this information coming from the consumer to adjust his own farming process.
- Consumer information is of course important but it is also a bit more dynamic and unpredictable than the question of production efficiency. You never know what it is going to be tomorrow that people are talking about and interested to purchase.
- For activities that needs to be performed within short time window effective communication and optimization is essential. At the moment in the farming business (compare to the forest industry) there is still a lot of room for improvements.
- Traceability from farm to fork is important. There are still holes in the food chain traceability. By providing traceability information from own products (e.g. documenting whole process in its details) it could be possible to get also better price from them and more meaning for own work.
- Vilppulan Tattariosuuskunta, a producer community in Finland, produces a few functional food products that for example corn allergic person can eat. The food is treated in a special way in the production process. They have special interest for this because they know the process from thoroughly and can generate added value from it.
- Consumers are interested in how their food is produced.

The end-user evaluations concerning the Smart spraying concept confirmed the potential of the innovative solutions of the Smart spraying concept. When discussion took place with farmers who have previous experience of ICT-based farming technology the potential advantages of the Future Internet –based technologies could be identified. The farmers also saw broader benefits of the FI-based farming like new forms of collaboration and learning.

On the basis of end-user feed-back and developing inputs of FI generic enablers the concepts were developed further. New elaborated versions of the conceptual models are provided in the present report in section 2.1.2.2.1

Step 5: Scenario-based concept construction

Bizagi modelling techniques was used as a tool in the conceptualisation of the functioning of the system architecture in the use cases with the aim of which the pilot would be demonstrated. This step was engineering-oriented but exploited end-user evaluation results achieved so far.

Next steps

In the present deliverable the accomplishment of the 6th step of the validation and the results will be described. The reporting of the final step 7, which includes the integration of the Smart Spraying pilot to the experimentation of the large scale pilot in the eventual second phase of the Future Internet project, will be reported in the outputs of W600, i.e. D600.4

During the last months (after May 2012 until October 2012) of the smart spraying pilot development the concept was significantly elaborated. When the concept had thus far focused on smart spraying and a selected scenario, the concept scope was enlarged to cover also a smart farming service concept. The enlarged pilot can now be labelled as Smart farming Concept and it includes both service level and spraying concepts and proposals for corresponding user interfaces. The elaboration of the pilot will be elaborated in the following.

2.1.2 Final evaluation results of the Smart spraying/farming pilot (Finland)

2.1.2.1 Evaluation methods

The evaluation approached followed the V7 model. The 6th design and evaluation step was accomplished and several different methods were used, including a design workshop 2 with two separate sessions. Between the two end-user sessions the Smart spraying concept was elaborated further. The concept labelled Smart farming now includes two parts: The Smart service and the Smart spraying. These two parts have been presented to the end-users either on conceptual or also on user-interface level. Finally the elaborated concept was also discussed in the national panel organised within the WP700. These methodical means of gathering end-user evaluations are described below.

2.1.2.1.1 Design workshop 2: Evaluating the concept

Target: Test of the service and spraying parts on concept and corresponding user interface levels. The target will be approached via the design workshop 2, which includes two separate sessions and a user interface development that takes place between the two workshops.

Session 1: Vihti 28.6.2012

A workshop session was organised at MTT Vakola site in Vihti, 28th June, 2012.

<u>Focus</u>

The workshop focused both on the smart *service* (initial form) and the smart *spraying concepts* with the aim to elicit detailed data of the information needs of the famer in planning and accomplishing a spraying task. (User interfaces were not presented and dealt with in detail).

<u>Method and participants</u>

The Critical decision method [1] was used in the interview. The methods are applied individually. According to this method the participant is requested to propose a challenging event that s/he has personally experienced that would demonstrate the constraints in the task and system under study. Thereafter in several successive phases, called sweeps, the event is analysed in detail. The interview was audio-recorded and transcribed into a written protocol. Two farmers participated in the workshops (so far only one session has been analysed in detail but it will be included in the final report of the case which is going to be submitted in a scientific conference during 2013).

We also collected field data of spraying activity. This was accomplished by videotaping one entire spraying event by an overview camera and a head-mounted camera which shows the direction of gaze (but not eye movements in detail). This information provides detailed information of the actual use of information and accomplished operations during a spraying session. This data will be used when demonstrating the added value of an FI-based on-line support of spraying (to be included in the above-mentioned scientific report).

Concept and User interface development

<u>Focus</u>

As indicated above the Smart spraying concept and pilot was elaborated during the last design phase (June-October 2012) MTT Smart Spraying System developers and VTT human factors experts developed in collaboration the system to include two parts, the *service* and the *spraying* parts, and two levels i.e. *concept* and *interfaces* were developed for both parts.

<u>Method and participants</u>

This step comprised of technical and human factors engineering work in which MTT and VTT experts participated.

Session 2: Jyväskylä 25.-26.10.2012

<u>Focus</u>

The smart farming *service* and *spraying* concepts and corresponding *user interfaces* were presented and evaluated.

<u>Method and participants</u>

The developed concepts and user interfaces were demonstrated to the participants of a national KoneAgria fair (Agrimachine) in Jyväskylä at the 25.-26.10.2012. The concept was described on a poster and was explained to interested visitors to the MTT stand by the researchers. The user interface was demonstrated on computer screen and also by smart phone application. 15 interviews could be completed among the participants of the KoneAgria fair.

National discussion panel 24.10.2012

<u>Focus</u>

As an activity of the WP700 VTT and MTT organised a national discussion panel at VTT Otaniemi site, on the 24.10.2012. In this session four pilots Fruit and Vegetables, Tracking, Tracing and Awareness Meat (TTAM), Tailored Information for Consumers (TIC) and Smart Spraying pilot were presented to the participants for comments. The Smart spraying pilot was presented including the *service* and *spraying* parts, and it was discussed on *conceptual* level (the user interfaces were not discussed in detail).

Method and participants

The pilots were presented in about 10-15 minutes presentations. The presentations were prepared by the Finnish SAF research group. After the discussion panel we had a common group discussion within the research group to filter out our main conclusions of discussion: the key points from the discussion, relevant for the pilots, concerning in particular information production in the food chain and information management.

In order to get more diverse response from the participants, the 5-page questionnaire was developed and shared in the beginning of the meeting. These questions considered the views on the main challenges of the food chain, the effect of the pilot on the process development, the challenges and threats of the usage of the pilot and views on changes in business environment. One of the researchers recorded in writing all the discussion and a back-up audio-recording was also taken.

18 end-user representatives participated in the panel. 5 researchers were present to support the discussions and recording.

2.1.2.2 Results

2.1.2.2.1 Focus of evaluation: Concepts

Overview of the smart farming concept

The original overview model of the smart spraying concept was improved according to the elaboration of the pilot MTT and VTT decided to accomplish. The main elaboration concerns the inclusion of a *Smart farming service framework* part. It supports the initial *Smart spraying system* part. As a consequence the final concept has two parts, as depicted in Figure 2.

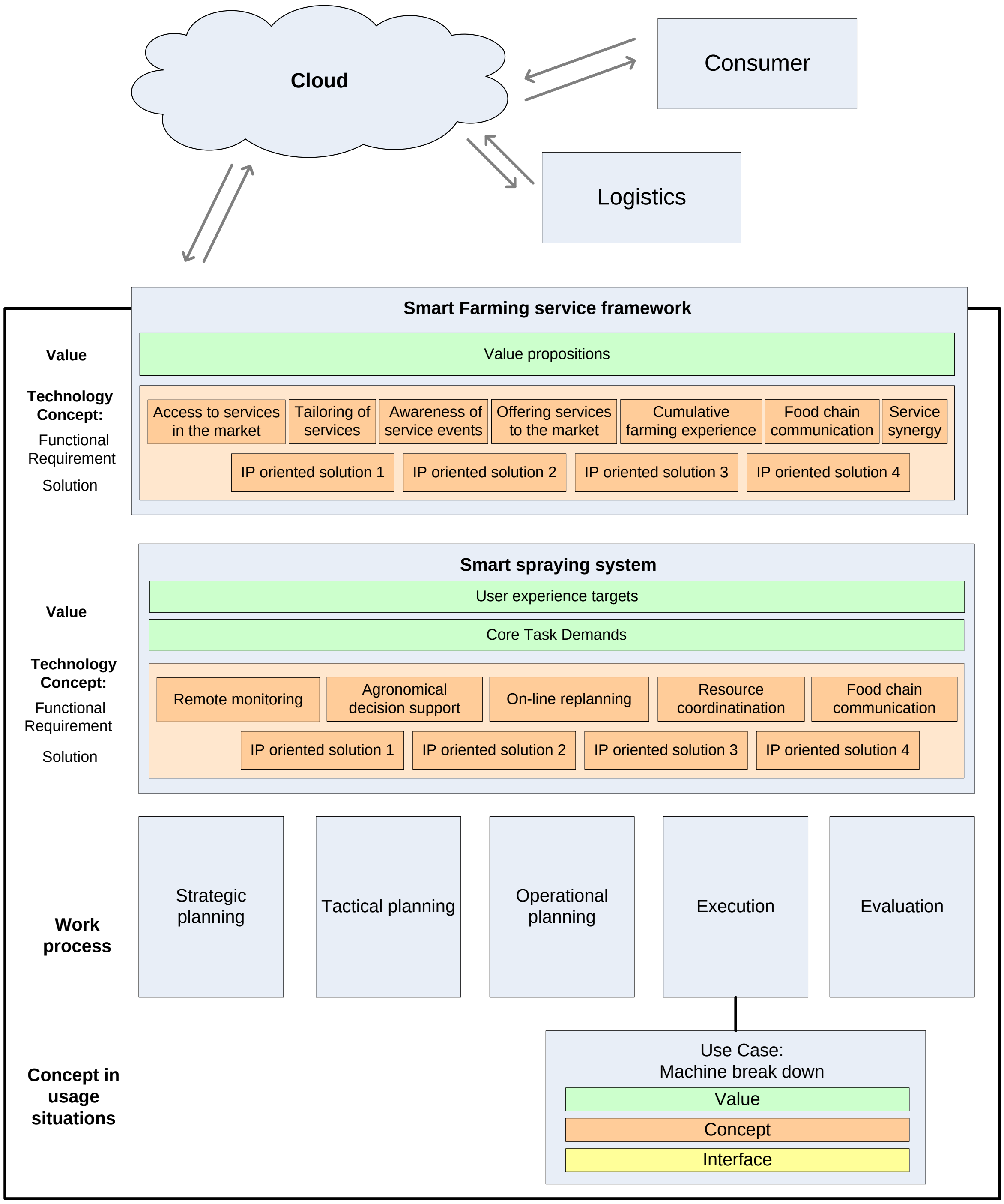


Figure 2: Smart farming concept overview.

The model also demonstrates that the smart spraying concept has been elaborated with regard to one work process phase, i.e. execution. The use case used to elaborate the Smart spraying concept element is “Machine break down” scenario. This scenario is described in detail in D200.3.

The Smart farming pilot conceptualisation is always accomplished on three levels: *Value* (green level), *Concept* (orange level) and *User interface* (yellow level):

- The *value level* refers to value propositions concerning the activity under discussion (also business models) and the core-task demands of the work to be accomplished with the aid of the defined system. Included are also so-called user experience targets (UX targets) which define work-related expectations with regard to the development of work when the new system is implemented.
- The *concept level* refers to the usage-driven requirements and the solutions that are proposed to fulfill these requirements. This level is supposed to define the innovative features of the designed concept from the point of view of the aimed work or usage. Because the work or other usage is described in functional terms, i.e. in generic core-task demands of the work and value propositions expected to be reached when enabling technologies are introduced, the description is future oriented.
- *The user-interface level* refers to specifically usability-related (requirements and) solutions. These parts of the model are not presented in detail conceptually but instead are demonstrated via visual solutions.

Smart farming service framework

As indicated above the Smart farming service concept (as well as the Smart spraying concept) was defined on three levels, i.e. value level, concept level and user-interface level. The proposal for the Smart farming service framework is to be found in Figure 3.

Value level: In the case of the Smart farming service the value level was defined with regard to the added value of the proposed concept. The added value that was found relevant for the farmers are expressed in the form of value propositions presented on the “green level” of the service concept model in Figure 3. Five value propositions were formulated.

- Networking, i.e. access to services
- Providing more high-quality food products
- Documenting all processes
- Environmentally friendly production
- Improved resource management

With regard to *Networking and access to service* possibilities to create links between machine manufactures, governmental agencies and authorities, industries processing their products were conceptualised. These links are seen particularly important in the planning phases of the production work. There is also an on-line need for access to services while accomplishing particular farming tasks, e.g. spraying. A seamless spraying experience is valued as a future expectation what regards the execution of work on the field.

Providing more high-quality food products was also conceptualised as an important value added by the Smart farming service framework. Improving high quality is possible due to better planning that the network could support, e.g. in the form of better mastery of chemical interactions when selecting spraying substances, but also due to the on-line services that could be provided for monitoring and alarming of plant diseases. It has become clear during the planning of the concept that farmers are well informed and concerned of the need to control well the residues of chemicals in the final products.

Documenting all processes in farming is a demand that characterises a modern farming activity. Smart farming service concept should enable better reporting and facilitate more automatic recording as much as possible. An improved reporting is a possibility for them to establish high-quality brands. Reporting should increase trust within the food chain, and also improve the possibility to inform the consumers about the products. In this connection also more generic benefits for registering could be identified. Advantageous for the future development of the agricultural domain would be that better information of farming activity could be delivered to the governmental bodies and to research.

Environmentally friendly production was also considered as an added value of the Smart farming service framework concept. In this connection the benefits were clearly connected to better control of the chemicals used, and via this, better justification their usage in fighting plant diseases or insects.

The final value proposal that was identified concerned the *improved resource management* of the entire farming activity. It is clear the good planning is important and it could be facilitated by FI-enabled networks, but on –line resource management in highly intensive working periods of the growing period would also provide added value.

Concept level: On the concept level of the Smart farming service framework all together 7 concept elements were identified. The elements indicate what are the innovative features that the Smart farming service framework would provide for the users. We identified the following innovative features:

- Access to service in the market
- Tailoring of services
- Awareness of service events
- Offering services to the market
- Cumulative farming experience
- Food-chain communication
- Service synergy

The innovative concept features are depicted in Figure 3 as the upper “orange level”. These features are thought to enable a new type of farming work. The features enable purchasing of services for own production and it also facilitates offering services for the farming community, or to the market. Accumulation and delivery of information for farmers’ own benefit and learning and also throughout the networked farming activity and food chain, are also enabled by the proposed concept.

On the concept level we identified seven solutions that would be needed to realize the designed concept. These were (see also Figure 3, lower “orange level”):

- Marketplace registration
- Service registration
- Easy change of service provider
- Notifier (alarm) integration
- Vertical information exchange between third party services
- Use of IoT service enablement for open service building
- Third party service user interface exchange and embedding

The above solutions were identified in close connection with the MTT technology developers (especially Markku Koistinen), and are integrated in the design Smart farming service design based on the FIWRE generic enablers (see D200.3).

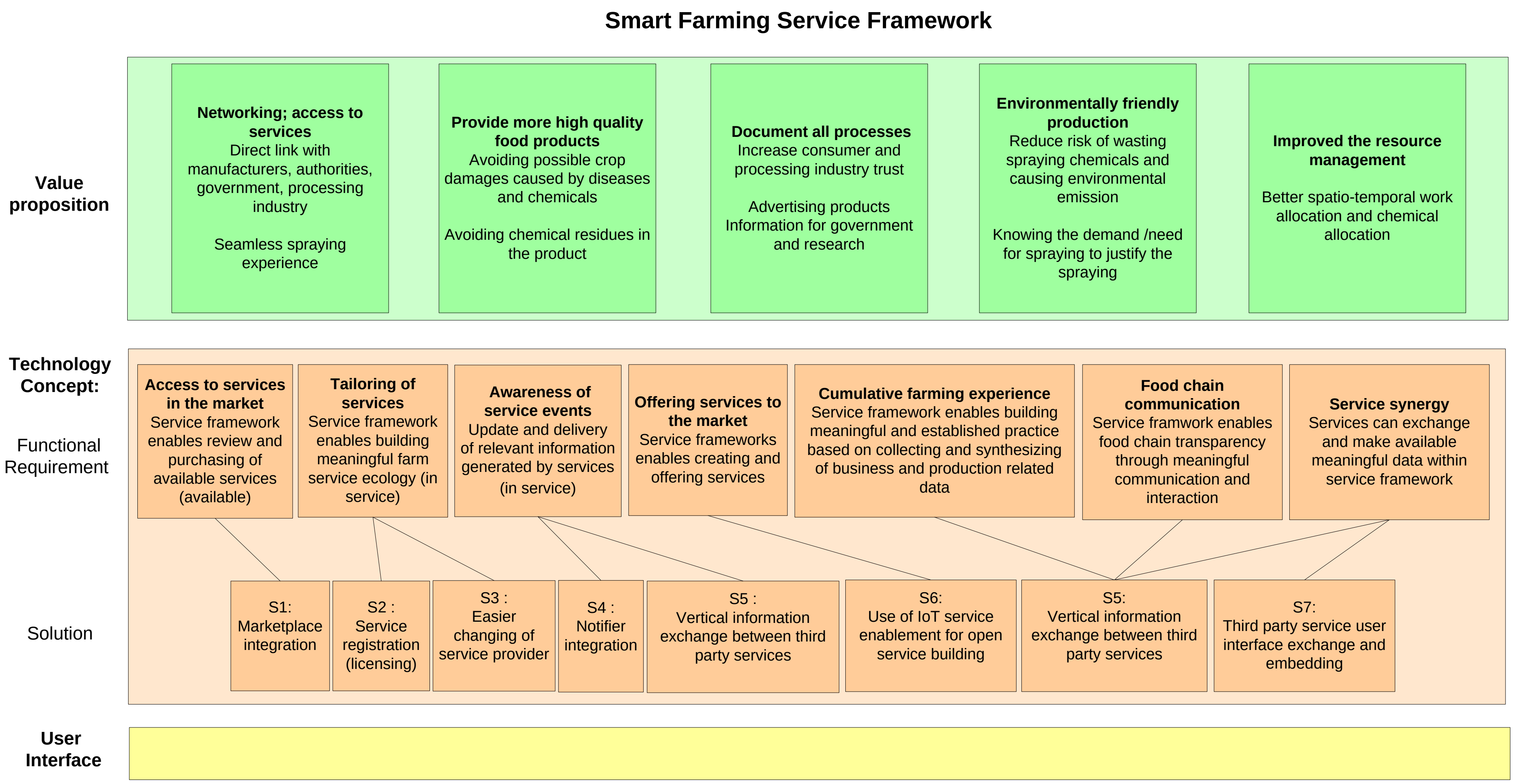


Figure 3: Smart farming service framework

Smart spraying system concept

The Smart spraying system concept is presented in Figure 4. The *value level* (green) of the Smart spraying system focuses on the core task demands on the actor and the user experience targets (green).

We succeeded to identify 6 major core-task demands to the Smart spraying work. These were derived on the basis of earlier core-task definitions for precision farming [2] and concretized to fit the particular work of spraying. The core-task demands describe psychological work demands that are necessary for fulfilling successfully the aims of the work. The focus in defining the demands is in the goals, constrains and possibilities of the farming process itself. In each box of Figure 4 (green), the bolded title defines the core-task demands of farming activity, under which typically three sub-demands were identified (normal text) to apply in particular the smart spraying task. The aim is that the technology concept developed should fulfil these demands.

The user-experience targets are seen to follow from the logic according to which the farmers take the core-task and production related demands into account and what they consider as good professional work. The user experience (UX) targets is the final result of the end-user evaluation of the Smart Farming pilot and we shall return to it in the end of the result presentation in section 2.1.2.2.4

With regard to the *concept* level Figure 4 provides the main innovative features of the Smart spraying technology concept from the point of view of the farmer. Functional requirements and the solution are identified. The thereby defined technology concept should support the fulfilling of the UX targets and the core task. We have identified six concept level functional requirements and five solutions that should fulfil them. The *functional requirements* that we thought to be of most importance to the famers in their spraying task are:

- Remote monitoring of spraying
- On-line re-planning of spraying task
- Resource coordination including human actors and automation
- Agronomical decision support
- Cumulative operating experience
- Food chain communication

Details of the requirements are indicated in Figure 4, upper orange boxes.

The innovative features of the concept include also the *solutions* that should tackle the requirements. The solutions are based on Future Internet technology. This enabling technology provides characteristics to the system that are novel also to those farmers who have experience of Farm Management Information Systems, or who are used to exploit Internet services for specific needs.

The innovative solutions from the farmers’ point of view are proposed to be (see also Figure 4 lower orange boxes):

- Tailored services by combining internal and external data
- Aggregated recommendations for on-line decision making
- Task-aware and timely presentation of information
- Context-aware work support
- Synthetic feed-back from operations
- Food chain communication

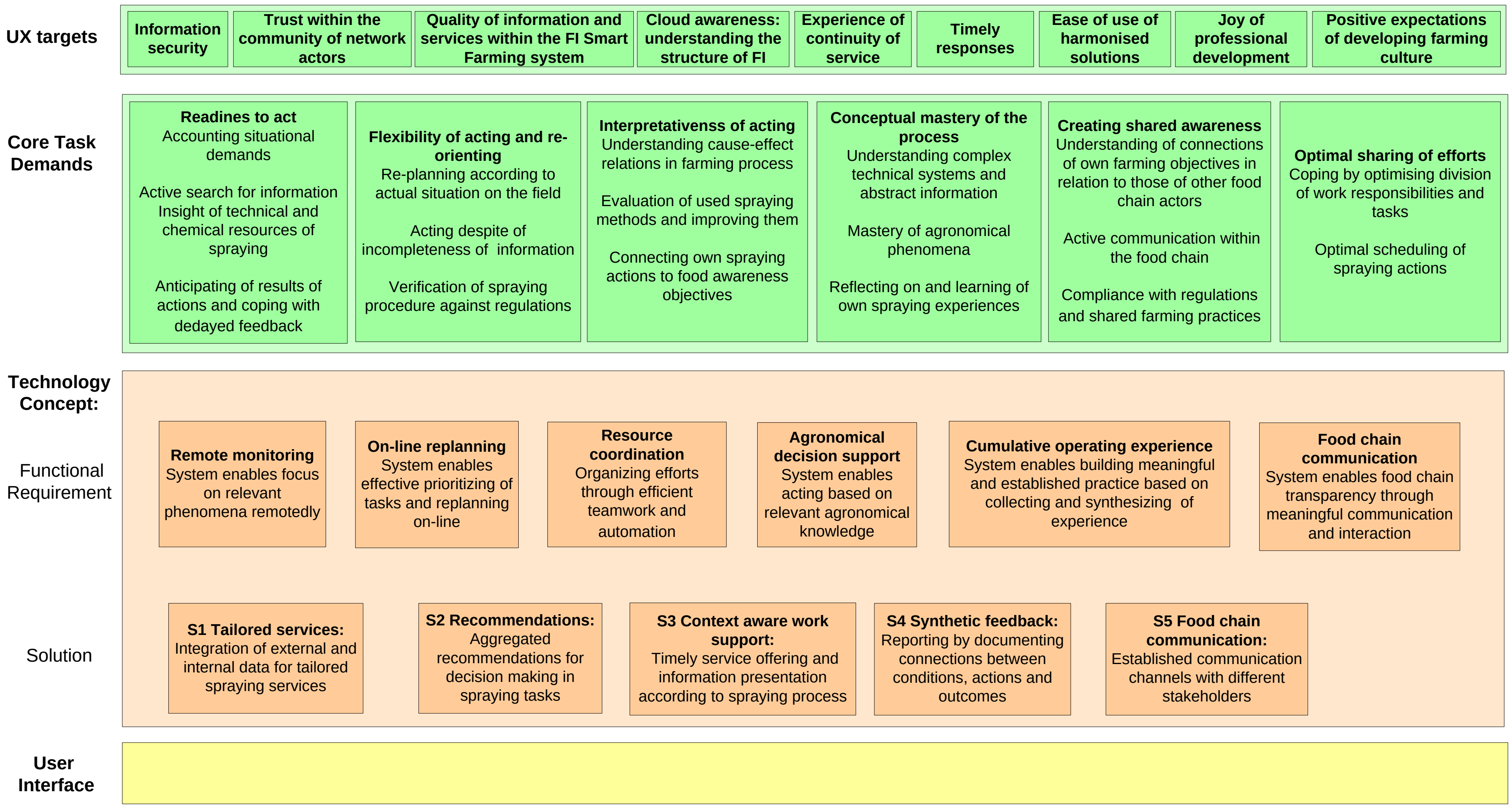


Figure 4: Smart spraying system concept

This model was made subject to user comments in the design workshops organised during the design. Questions that were to be discussed with end users were:

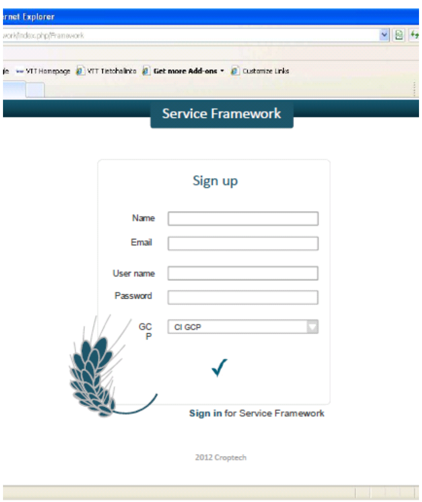
- Which work demands are considered as a design basis? (focus on the green boxes)
- How the work demands are represented in the functional concept requirements? (focus on the relationship between the green and orange boxes)
- Are the concept solutions in accordance with the set concept requirements? (focus on the relations between the two levels of orange boxes)
- Does the concept solution have potential to support work demands and functional as an appropriate tool? (focus on the lower orange boxes).
- Does the new concept have impacts on the concept of operation and working practices in spraying?
- Does the new concept have impacts on business models and dose it appear to open new possibilities in farming business?
- Does the user interface solution realize the concept solutions? (focus on the yellow box-es)

2.1.2.2.2 Focus of evaluation: User interfaces

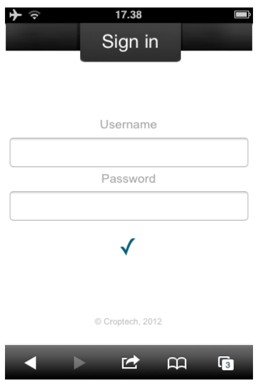
In this section we shall describe the proposal developed for the user-interfaces for both the Smart farming service and the Smart spraying. For the Smart service both lap-top and mobile device versions were created.

Smart farming service interfaces

In order to take the Smart farming service framework into use and build an own service ecology the users are required to sign up as a user for the framework. This is done through the Signing up page. After signing up the user can sing into the Smart farming service framework via Signing in page.



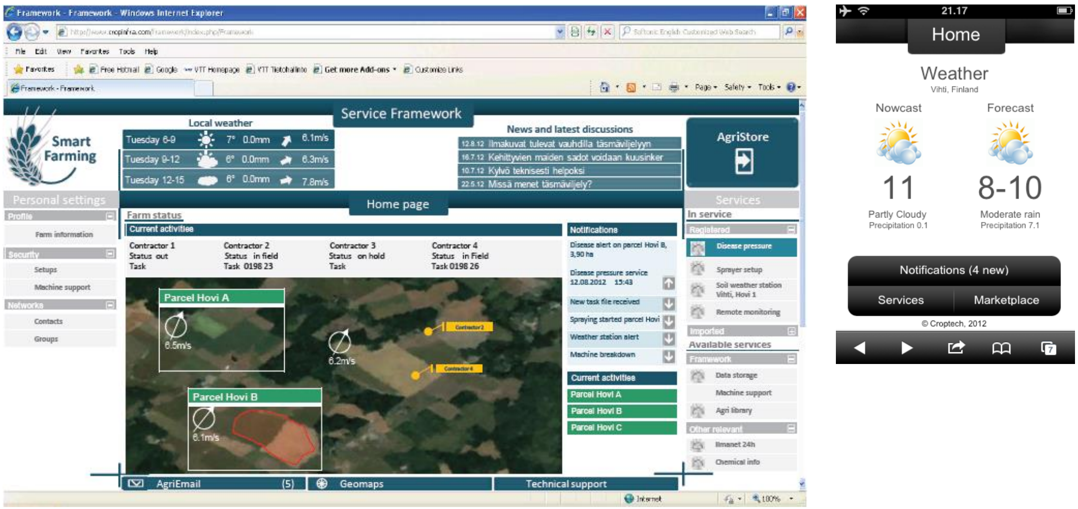
a)



b)

Figure 5: Smart Farming Service Framework UI, a) Signing up page and b) Mobile Signing up page.

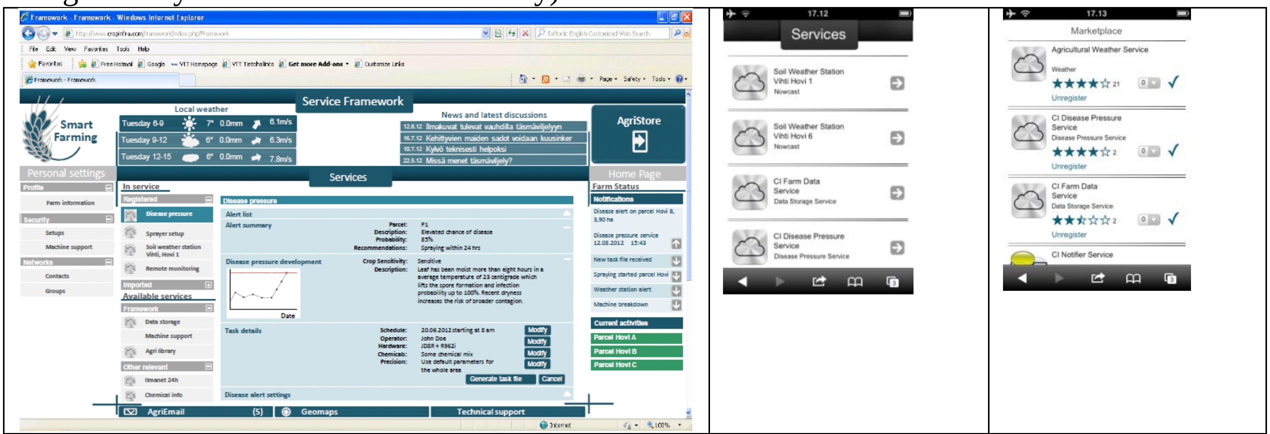
After performing the signing in successfully the Service Framework Home page will be dis-played. When taken into the use the Smart farming service framework would provide the user with some basic information elements and functionalities such as; local weather information, news and latest discussions, access to regional maps as well as email address and technical support (see upper and lower bar in the Figure 6). The Home page of the Smart farming service framework (in the middle of the display in Figure 6 and Figure 7) is reserved for the most crucial information (e.g., detailed weather forecasts, notification messages and alerts). A central design goal has been to be able to display all this farm situation related information in one view so that the user could easily comprehend an understanding of the prevailing farm situation. The real-time status information that is shown in the Home page display is generated by the service ecology that the user has built for him and therefore it is tailored to the needs of each individual Smart farming service framework user.



a) b)

Figure 6: Smart Farming Service Framework UI, The Service framework Home page can be accessed through a) a work station and b) mobile devices.

From the Smart farming service framework Home page there is an easy access to the Services page (see Figure 7). In the Services page the user is provided with a view and access to all relevant services. It also enables the user to manage his personal service ecology; view and adjust services that are registered into the service framework implement (services that are in service for the user), view and connect globally registered services and IoT devices (e.g. weather station) that might have relevance in the service framework and view and purchase relevant services offered via marketplace (services that are available for the user). In the Services page from each service (in service or available for the user) basic information is presented in an uniform format (e.g. name of the service, short description of the service, service producer and possible service rating done by the service user community).



a) b) c)

Figure 7: Smart Farming Service Framework UI, Service view. a) provides an overview of the service offering as well as the more detailed service specific information. b) and c) Provides an overview of the service offering and easy access to the more detailed

Smart spraying interfaces

Figure 8: Smart Spraying System UI, Disease alert received

Figure 9: Smart Spraying System UI, Preparing and downloading task file

Figure 10: Smart Spraying System UI, Machine malfunction alert received and the problem inspected

2.1.2.2.3 End-user responses

Results from the workshop 2 and national panel will be summarised with regard to the Smart farming service frame and Smart spraying concept. (The Vihti interviews in the first session of the second workshop are not included.) The interfaces were demonstrated to the end-users and first responses collected during the second session (Jyväskylä 25.-26.10.2012) of the second design workshop.

General observations

This pilot (including the service and the spraying concepts) was seen as interesting both by the panellists, and by the interviewees (out of which 10 very positive, 4 neutral, 1 hesitant). The technology used was seen very interesting, but the main concern is linked with the size of the farms – how large the farm should be, to be able to cover the costs of the application compared to the benefits given by the pilot. In the future, the farm size is increasing in Finland and therefore, this pilot was seen as belonging to the business environment of the ProAgria Association (farmers' advisory association). The panellist thought, however that from the farmers point of view the work processes on the farm have been evolving during many years, on-line weather information is needed, but spraying (cereals) is normally done the same year after year and also the groundwater areas etc. are quite well known by the farmers.

The global goals of the food chain were spontaneously not discussed by the interviewees. Only one person of 15 interviewees took these up. This person noticed appropriately that the FI and its applications in farming will have a very broad social impact. He also noticed that policy and regulatory aspects need to be taken care along with the technical development. This would also improve the information content of the service, as up-to-date regulations would be easily accessible in the applications. He saw that FI-based systems would support management of environmental goals, improve the transparency and facilitate attention to end-user needs.

When, in the case of the panel the panel members were deliberately queried about the global goals the results were as follows (Table 1).

To which general goal the pilot contributes? (Numbers indicate amount of responses)

7	Food safety
11	Control of environmental effects
3	Responding to the demands on diverse consumption cultures

2	Ethically sustainable food chain

Table 1: General goals that the Smart farming concept supports

According to the acquired feedback from the end-users in the following results could be achieved concerning the concept, its possible use, and user interface.

Key features of the concept (number of responses in parenthesis)

- As available information increases it is significant to structure the information appropriately 10
- Compatibility between different systems 9
- Reliability of information and security issues 7
- Automatic input of information, automatic registration 6
- Development of a practical service pilot would be beneficial, management and maintenance are challenges 6
- Costs of services are a major challenge / are not a particular problem 5/1
- Farm conditions and farmers' needs are the starting point of service design 4
- Training (or new generation of farmers) is needed and motivation will have to be developed among the farmers 3

Usage areas

- Collaboration and networking 5
- Interaction between production and consumption 4
- Demonstrating good processes and quality as source of brand development 3
- Sub-contracting 3
- Labour market 2
- Development of new business opportunities 2
- Remote control of farming/ animal processes 1

User interface requirements

- Excellent usability is a key issue: easy to use, easy navigation, guidance, no memory requirements, easy to find extra information 11
- Dependability and good internet connections 6
- Decision support but final decision by the farmer 1
- Preferably use Finnish language 1

Impacts of the Smart farming concept on farming work

In the questionnaire filled in by the national panelists we also inquired the participants how they felt that the Smart Farming concept would effect the efficiency of farmers' activity. As the Table 2 and Table 3 below indicate the increase of efficiency was assumed to be moderate, and reduction of workload also moderate.

The new possibilities presented in the pilot contributes to the effectiveness of work?

No resp.	not at all
1	a little
5	somewhat
3	much

1	very much

Table 2: Impacts of Smart farming concept on the effectiveness of work.

The new possibilities presented in the pilot supports work and reduces work load?

No resp.	not at all
2	a little
5	somewhat
3	much
	very much

Table 3: Impacts of the Smart farming concept on work support and reduction of work load.

The respondents found however, as the Table 4 (below) indicates, that work would be developing and learning possibilities would be increasing.

The new possibilities presented in the pilot supports development of work and learning?

No resp.	not at all
1	a little
3	somewhat
6	much
	very much

Table 4: The impacts of the Smart farming concept on development of work and learning

In conclusion of the end-user validations we may state that end-users were able to comprehend and get interested on services that could be opened to them via the FI technologies. In the earlier interaction with the end-users in 5 different countries the end-users expressed doubts and even somewhat pessimistic responses (See step 2 of the design process, Section 2.) When we presented a systematically defined concept and demonstrated a proposal for the user-interface and discussed it with the end-users they were much more positive towards the future possibilities.

Both the end-user feed-back from the national panels, and that acquired during the design workshops integrated in the design process, convey the message that farmers are aware and concerned of the generic challenges of the food –chain, i.e. food safety, environment, ethical issues and cultural preferences. The consideration of the global challenges becomes evident in the decisions taken when accomplishing the farming activities. Especially the food safety and environmental challenges were considered in concrete and criteria were identified how to optimise between these goals and efficiency of work. Cultural preferences or ethical issues were not identified as central challenges by arable farmers. It may be assumed that these challenges are more relevant and readily dealt with by representatives of animal farming.

As a result of interacting with the end-users we were able to design Future Internet Smart farming concept that corresponded the expectations that they had expressed. This could also be verified with a positive response by the end-users towards the Smart farming service concept including a certain set of value propositions.

The end-users did see benefits of the proposed service and spraying concepts what regards to increasing effectiveness of work and reduction of workload, but in particular they found possibilities to develop the work, create learning and improve competences. These positive effects are due to the improved utilisation of information for understanding the complex agricultural phenomena of farming, and due to the possibilities to interact within the network of farmers, and even the wider communities of the entire food chain. Direct links to consumers was seen positive from business, safety and product quality point of view.

Even though the overall response was quite positive there were issues that clearly need attention when the Smart farming concept is developed further. The most pressing issues were related to efficient management and processing of information, compatibility between different systems, reliability of information and security issues, and automatic input and registration of information. The end-users felt that the development of a more concrete practical pilot would be very beneficial, with the aid of which the development of the concept could continue until the final delivery of the system. It was also considered that education and training is needed for the current farmers to be ready to adopt the proposed farming concept and that the wider appropriation of the system probably requires the new farmer generation to take over the business.

2.1.2.2.4 UX targets to be used in further development of the pilots in the 2nd phase

The end-user validation accomplished in the steps 4, 5, 6 of the validation concept is expected to produce a set of user experience targets, i.e. UX targets. These could be used as a basis for the final evaluation of the technology concept in the future. At present a tentative list of UX targets is

- Information security
- Just sharing of costs within the value chain
- Trust within the community of network actors
- Quality of information and services
- Smart information filtering mechanisms
- Cloud awareness: understanding the functions and basic structure of FI services
- Experience of continuity of service
- Timely responses
- Ease of use of harmonised solutions
- Joy of professional development
- Positive expectations of developing farming culture

In the future development the UX targets will be elaborated contextually, and used as basis for constructing an evaluation framework for systems usability of the smart farming concept. In this development the previous work on Systems usability of VTT will be utilised [3].

2.1.3 Intermediate evaluation results of Smart greenhouse management (Greece)

The step 6 of the 7 step V-model (Figure 1: The usage-driven design and evaluation model, the V7 model, used in the WP200) aims to actively involve the users with the testing and validation of the Greenhouse pilot. The target is to present the concept to them in a general way (suitable for a non ICT audience) while in parallel include detailed analysis of some key scenarios regarding information needs. Furthermore, the users will test the developed user interface. In other words, we aim to quantify how promising the designed FI-based Smart Farming System is to the users. Also, the contribution of the users to Experimentation specification of Phase II will be discussed. The participants' feedback would be used as an input for further development in the context of WP600.

2.1.3.1 National Discussion Panels

Within Task 710 OPEKEPE and NKUA have organized until now 3 national discussion panels with the objective to discuss the outcomes on the developments of the use case scenarios with the end-users and the ICT solution providers and to get feedback and provide input mainly to the WP200 but also to the WP300, WP400, WP500 and WP600. In each meeting were around 20 participants from ICT sector (5), farming (9), logistics (1) and agriculture (5) sector.

2.1.3.1.1 1st National Discussion Panel

In the first national discussion panel (11th April 2012) the results of the use case scenarios have been explained on a plenary session. The participants were split into 2 smaller groups (farmers - logistics -agriculturists, ICT specialists) and issues of specific interest were discussed like what is the SmartAgriFood project, the pilots from the WP200, WP300, and WP400 were introduced to the participants and after that the following questions were discussed with them. We shortly presented their feedback to these questions with especially emphasis to the last one that we have taken into consideration during the implementation and refinement of the pilot.

- What do they think about the technical solutions applied?
    - Overall solutions could be useful and will be probably applied by the potential users.
    - Most of the participants thought that the systems have a lot of functionalities that are useful for the efficient management.
    - The security of the data is very crucial for the technical solutions that will be provided
- Do they envisage any other applicable solutions which are relevant?
    - Users have to see benefits of services, functions and new methods. Usually aim is to achieve cost efficiency.
- Are the forecasted solutions applicable and how can they apply?
    - Feedback information about collected /transmitted data by the different actors or services back to the farming processes was seen as very valuable and promising
    - Evaluation based on real data gives more reliable estimations for the different planning levels.
    - Confidence to the user supporting functions is based on reliability of the solutions in the future.
    - The solution of Greenhouse Management will be applicable with usage of large amount of sensors and high resolution cameras.
- What are the potential hurdles of applicability?
    - The farmers and end-users are worried about the cost of the sensors, the cameras and the investment - the large amount of sensors requires a higher cost for implementation

- Currently getting a huge amount of information (even undemanding) is a key problem
- Another issue that has been discussed is how the farmers and users are ensured that the data that come from the systems and stored in the cloud are accurate.
- Biggest question and worry was reliability of the functions and services of the pilot. Especially security issues were emphasized during the discussions.
- Lack off two-way information exchange between stake holders was seen as a threat

- <u>What should the solution providers change or improve?</u>
  - Clarification of the services must be described in more detail like what are resources and costs of services and how the maintenance and continuity is realized both in cloud and cloud proxy.
  - There is a need for more efficiency in operations and less investment for users.
  - Systems should be reliable and should assure the privacy aspects and security measures.
  - Furthermore, most of the farmers requested from the system to simplify more the procedures that are related to the authorities or even automates them.
  - There is a need for applications which will help the direct connection between the authorities and the farming society.
  - Systems need to be flexible and open for use within a dynamically changing network
  - Systems should not build on a centralized system or management organization

2.1.3.1.2 2nd National Discussion Panel

In the second national discussion panel (2nd July 2012) were presented the videos related to the Greenhouse pilot and the slides referring to the mockup of the Greenhouse and Spraying scenario. Participants were left to navigate to the updated interface of the mockup and the terms as stakeholders, e-agriculturist, task plan analyzer, etc. were introduced once again. The main concepts/functionalities of the pilot that were presented were the following:

- E-agriculturist service
- The cooperation of stakeholders concerning all stages of cultivation
- The view of the farm through cameras and the control of the farm over internet
- Monitoring the sensed data, if sensors have been installed in the farms.
- The day by day updated program created by the task plan analyzer
- The problems documented and solutions proposed by the system
- Access from anywhere and at anytime
- The continuity of work even if the network is down
- Search for stakeholders and services and incorporation of them in their profile

The ICT panel was also given with the opportunity to interact with the real implementation and mostly with the account of the service provider. The participants agreed that the presented mockups were:

- really user-friendly and useful
- the functionalities of the mockups are captured in an easy and understandable way to the farmers and the agriculturists

According to the audience the following value propositions seemed to be missing from the concept:

- Transparency of crop production in the farms, correct information, sharing information, creating added value
- Possibility to create methods, systems and supporting functions that help farmers to act by the rules and to follow the rules easier, precise use of information e.g. legislative rules or latest knowledge of the farming
- New contracting services for the farming business, and creates also new demand for contracting
- User friendly methods to the farms to deliver needed document for the different authorities
- Equal and sustainable production chains between different actors for the food production e.g. Suggestion is to build an application for farmers to invite to tender for selling products (e.g. grain)

After that a list of the innovations was discussed. The general feeling was that all the participants were pleased to see that the Greenhouse pilot is on-going and a significant progress was made since the date that the first national panel was held. We discussed in more detailed way the novelties that arise though the SmartAgriFood project and especially the pilots of WP200 – SmartFarming and the list of the innovations discussed:

- Integration of services and the mashing up of information in a simple way for the farmer.
- Searching of services and stakeholders through repositories and registrars.
  - The participants were positive about this simple way of searching. A discussion was made about the huge amount of information that someone can find in the repositories and registrars and how difficult is to take the needed data easy and fast.
- Transparent and easy to understand charging and accounting mechanisms
  - They believe that these mechanisms are crucial for them and should be easy and really friendly so the end users wouldn't be confused in their chargeable events
  - They noticed that the security should be one of the main priorities in this functionality to avoid unexpected chargeable events for the end users.
- Usage of social network mechanisms that will support trust among stakeholders and services as well as spread useful information in a simple way
- Usage of opinion mining or reputation schemes provide credibility to services and stakeholders in an automatic way

  - The audience underlined that the popularity of the voting systems could be affected by "fake votes" and that this should be taken into account for the reliability of the system
  - The participants claimed that if privacy issues are not taken into account, the ratings and the comments may mislead the end users.
  - Our answer was that policy rules will be developed in order to grant which user has the right to make ratings or comments and to whom stakeholder or to which service.

- Enable a farmer to change an FMS (Farm Management System) provider without losing his raw data
- Usage of an interface with the underlying network infrastructure and end-devices to collect data about their status and their capabilities and improve the end users' experience
- Enhancing the FMS system with dynamic learning mechanisms
  - They thought that the most interesting was the learning of the system to predict the internet connection failures.
- Reconfigurable mechanisms to enable local mode of operation if there is no connection to the Internet
- Self-configuration, self-optimization and self-healing mechanisms in different points (equipment, cloud proxy, Cloud FMS)
  - the expert system will inform them through the fault management functionality in order to avoid any undesired operation
- Secure transactions
- Interfaces to the whole food chain since it designed to communicate with the logistics and the food awareness subsystems
- Enable service developers to design and deploy their services in a simpler way

2.1.3.1.3 3rd National Discussion Panel

At the third national discussion panel (November 5th 2012) all pilots were presented for ICT and end-users (logistics, farmers, agriculturists) participants but we focused on the Greenhouse pilot, Smart Spraying Pilot and Fruits and Vegetables pilot. After a short introduction to the SmartAgriFood project and the pilots the participants evaluated the potential use of the Future Internet into two smaller groups (farmers - agriculturists – transporter and ICT specialists) and at last the participants were brought all together for the closing session where the ideas came out from the parallel sessions where discussed.

The main results of this national discussion panel were:

- Most of the farmers cannot invest a lot of money to new machinery although they believe that this will save time and in long term they will gain some profit.
- Farmers who are not familiar with technology asked how easy would be to handle such a system and if they could be notified in their mobile phone for the position of the tractor, problems could arise during the procedure and the status of spraying.

- It was emphasized that it is vital that many different technologies are applied simultaneously, not only believing on one type of technology solution
- The technology used was seen very interesting, but the main concern is linked with the size of the farms – how large the farm should be, to be able to cover the costs of the application compared to the benefits given by the pilot
- Some of the participants own open kind cultivations so they asked if they can use this pilot and propose to extend the functionalities. Others needed some information about automated cultivation in terraces and especially in mountain and less favoured areas.

The requirements and the expectations of the audience were:

- The end-users wanted to know how much money should be invested and if they could start using the pilots now.
- The investment in software is relatively small compared to the investment in machines and other equipment. Therefore payment models like „Pay per service" are of minor importance.
- Some of the farmers said that the most important thing is to have fast internet access in order to be alerted in their mobile phone and also to have a clear view of their farms through the IP cameras installed.
- The use of the services should be easy and user-friendly
- Safety: avoid data loss by all means, even if application crashes before final step of sending data in an online application
- Traceability and quality management schemes are very relevant for all participants. The documentation has to be easy and based on the real work processes.
- The link-up of existing technical solutions (weather forecast, image processing for weed detection, etc.) was regarded as interesting by the participants. The control of the work processes should be left to the farmer himself and not to an autonomous system. The participants look forward to see the implementation not only in greenhouses but also for outdoor vegetable cultivation.

2.1.3.1.4 End user responses to the questionnaires

Additional to the National Discussion Panels, OPEKEPE also has organized a number of on spot meeting or phone calls with end users (farmers) from different places in Greece. In the beginning of each meeting or phone call we made a small introduction for the SmartAgriFood project that mainly was included a brief explanation of the different work packages, the project's aims and key concepts (smart farming, smart logistics, and food awareness) and the main achievement of the pilots of WP200, WP300, and WP400. Furthermore, we presented the innovative features of the concept especially for smart farming area (requirements and corresponding solutions) as we have done in the 2nd national discussion panel.

As it has mentioned in the D200.2, a mock-up that shows the design of the real implementation of the Greenhouse Pilot has been created. An online software application called hotgloo was used in order to specify the GUI that an end user interacts with. The mock-up is accessible via the link:

http://tsiort.hotgloo.com/wf/ce9da068

One of the aims was to provide all the above important functionalities that are included in it. The validation of mock-up was feasible via the creation of a questionnaire that each end user has filled after his navigation to the Greenhouse mock-up. We have followed the 10 Nielsen's Heuristics for our design and we have also made

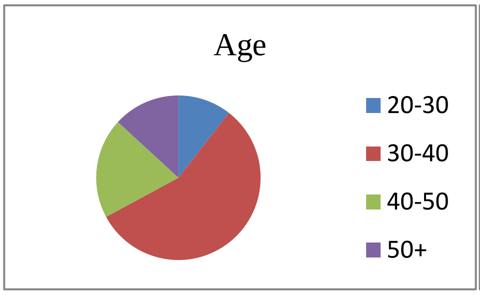
- One heuristic evaluations questionnaire that can be found in the following link:

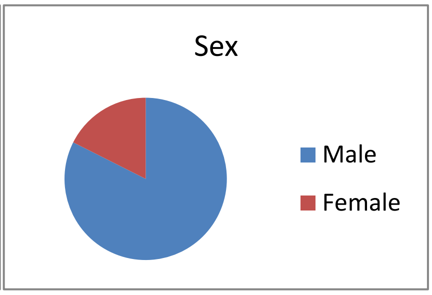
http://obsurvey.com/S2.aspx?id=3694E4C9-BFDF-4020-B79D-14A940E08AE8

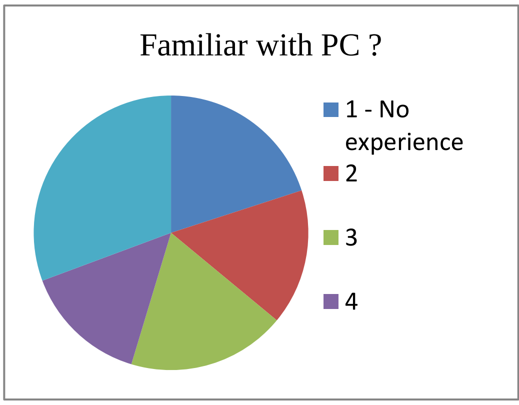
This one was given to stakeholders who had the opportunity to navigate the Greenhouse tool

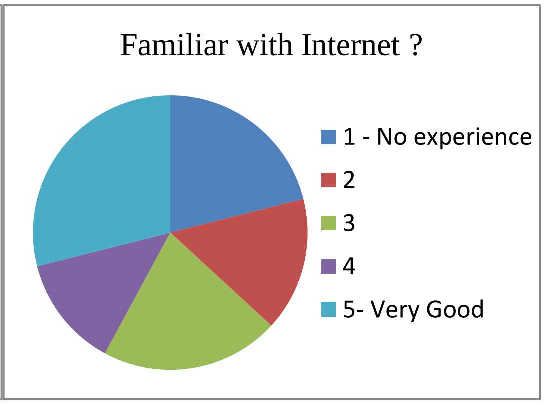
- Another one that can be found in the Appendix A of D200.2 and was shared to stakeholders who have participated in a presentation of the GUI without access to the electronic questionnaire

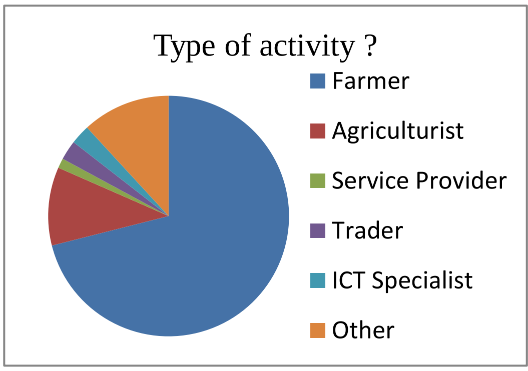
The main information and the conclusions of the 74 questionnaires are presented in the following paragraphs.

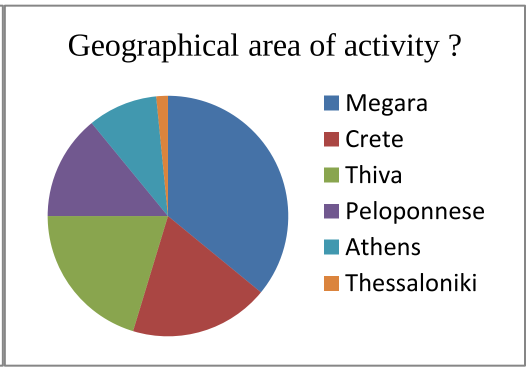


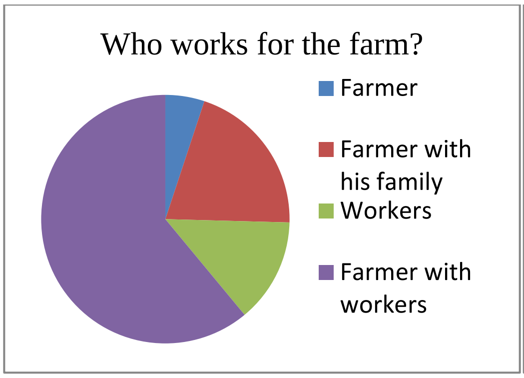


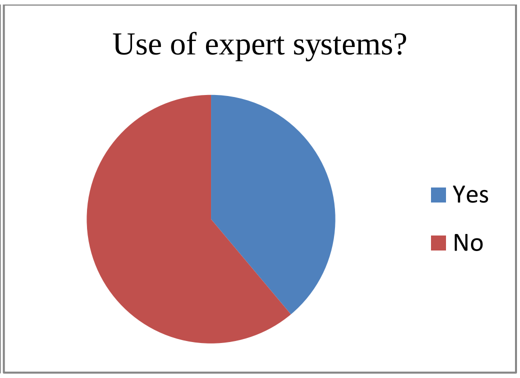


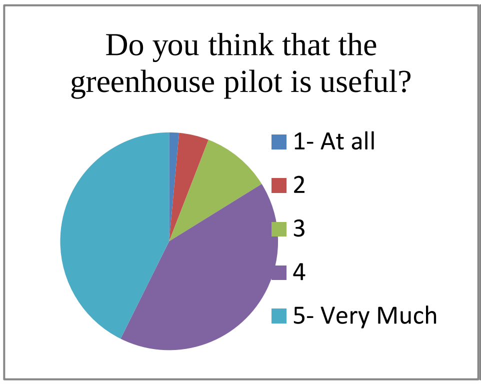


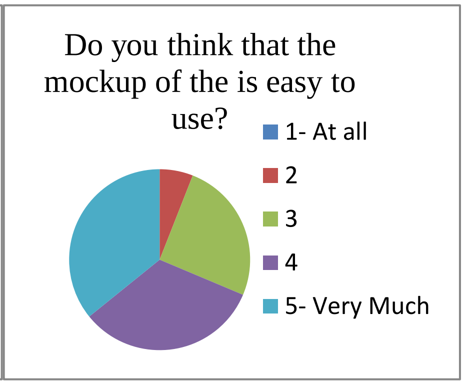


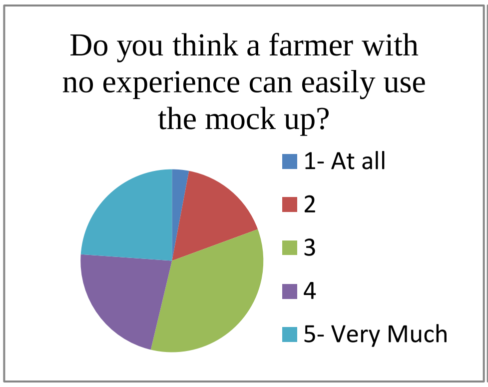


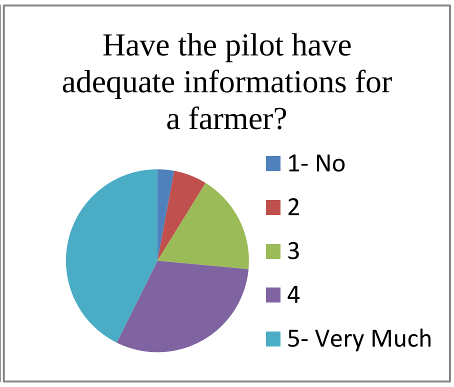

Who works for the farm?
Farmer
Farmer with his family
Workers
Farmer with workers

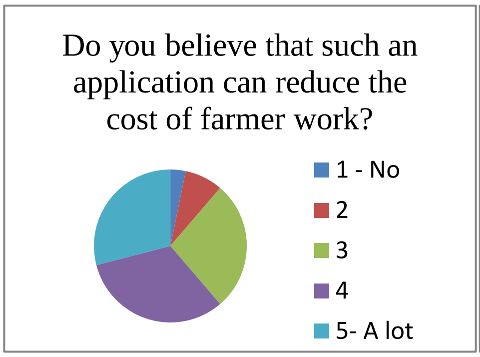

Use of expert systems?
Yes
No

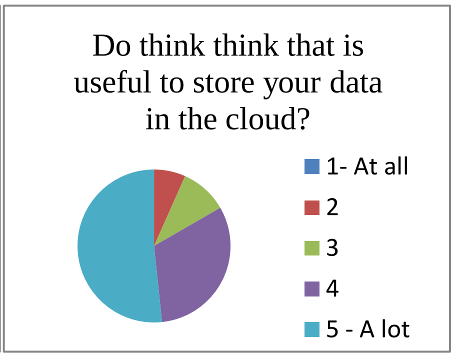

Do you think that the greenhouse pilot is useful?
1- At all
2
3
4
5- Very Much

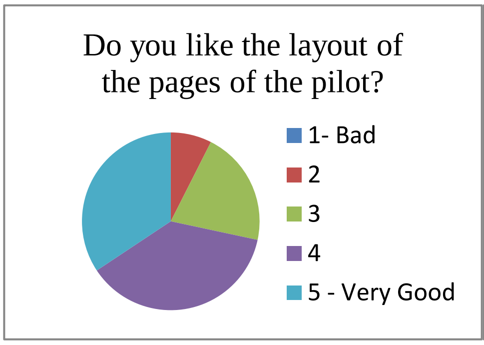

Do you think that the mockup of the is easy to use?
1- At all
2
3
4
5- Very Much

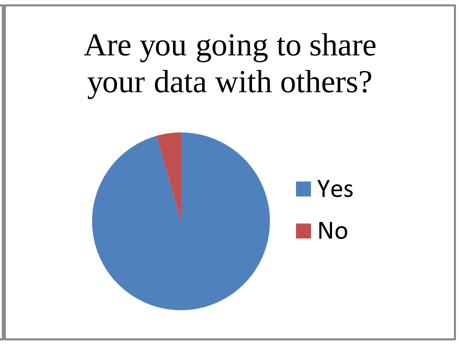

Do you think a farmer with no experience can easily use the mock up?
1- At all
2
3
4
5- Very Much


Have the pilot have adequate informations for a farmer?
1- No
2
3
4
5- Very Much


Do you believe that such an application can reduce the cost of farmer work?
1 - No
2
3
4
5- A lot


Do think think that is useful to store your data in the cloud?
1- At all
2
3
4
5 - A lot


Do you like the layout of the pages of the pilot?
1- Bad
2
3
4
5 - Very Good


Are you going to share your data with others?
Yes
No

To the question “which functionality do you think that should be added to the greenhouse pilot?” the stakeholders suggested the following propositions that the majority of them have been integrated in the real implementation of the greenhouse pilot:

- It should be added in the greenhouse a sensor for measuring the wind power.
- Extension of the pilot for the outdoor cultivation
- Best practice for the pest fight
- Historical data for the pest fight
- More categories of stakeholder to be added e.g. seed merchants
- A service which will inform the farmers for the trend to the consumers e.g. which is the most preferable tomato variety that the consumer buys
- Online service with the prices of the products
- Technical information about the resistance of the sensors depending the climate conditions of the area
- Statistical data about:
  - the annual production target for each product
  - the annual production per product
  - the demand for products by type and country
  - the price of the products per country
- Service that will provide the soil analysis per area
- Historical data about production, sales e.tc.
- Cultivation plan per year
- Service for inputting the audit results from different audit organizations
- Best practice for the lubrication e.g. what does each plant need?
- Inventory with the products, raw materials, tools etc.
- The current values of the sensor should be added in the main screen of the application (e.g. in a table) so the farmer could see them easily (like the stock options)

To the question “Is there something that would like to be changed to this version of the greenhouse pilot?” the stakeholders suggested the following propositions that the majority of them have been integrated in the real implementation of the greenhouse pilot:

- The colors and the size of the fonts that are used to the graphical interface
- The evaluation of the services or the stakeholders should be under strict regulations to avoid the defamation cases
- To be more clear the names of the type of the sensors (e.g. RH). What exactly do they measure?
- In the layout of the farm should be added the scale of the map and also the the cardinal points (north, south, west, east)

- In the entrance screen of the pilot it should appear a banner with the jobs of the day. The job schedule is not enough

To conclude the farmers would like not to invest a lot of money for the sensors and for the annual subscription in the implemented application (maximum 1500€).

3 Evaluation

3.1 Economical aspects

3.1.1 Financial benefit to farmers

The adoption of FI technologies will result in several benefits for the farmer with regard to the economic outcome of his enterprise. A more efficient use of fertilizer, seeds and pesticides will lead to lower costs and a higher production rate. The sales price of the farm product can be higher due to a higher quality of products (regional marketing, certification of the production process, better freshness) and due to a higher demand response. Better planning tools allow for less machine operations. Costs for energy and water can be saved by smart metering and dynamic tariffing. The use of cloud services will lower the costs for advisory and consultancy services and reduce in-office work hours. Finally, the capital investment for IT equipment can be lower, but the operating costs for cloud services are higher.

In order to quantify this economic benefit, a business case was analyzed. As an example, the situation of a medium sized crop farmer in Germany was investigated (Table 5). Financial data were obtained from [4].

Key Assumptions WITHOUT FI	**y1**	**y10**	
Area [ha]	167	174	
Wheat production [dt]	8 830	10 688	
Barley production [dt]	3015	2.838	
Wheat price [€/dt]	17.9	2.2	
Barley price [€/dt]	13.6	17.3	
Subsidies [€/ha]	354	470	
COGS [€/ha]	537	851	
- Fertilizer [€/ha]	196	307	
- Machines [€/ha]	94	234	
OPEX €/ha	366	425	
- Personal [€/ha]	81	116	
- Land lease [€/ha]	153	163	
Start CAPEX k€			611
- 2 Machine combinations [k€]			250 each
- Building [k€]			100
- IT equipment every 3 years [k€]			5

WACC			9%
TAX			3%

Table 5: Key assumptions for example business case

In order to quantify the economic benefits, numbers for all aspects have been estimated (Table 6). In most cases, only a moderate change due to the adoption of FI has been assumed. The major difference is in the costs for accountancy, planning and consulting, which declines dramatically, whereas the costs for FI services have to be added.

BC parameter	Impact of FI on value per y	Impact of FI on growth (CAGR) pp
Wheat , barley production [ha]	+0.5%	+0.5%
Wheat , barley price [dt]	+2%	+2%
Fertilizer [€/ha]	-1%	-1,%
Pesticides [€/ha]	-1%	-1%
Heating, water, electricity	-2%	-0.5%
Accountancy, legal, planning, consultan-cy	-50%	-1%
FI services	+6k€ (500€ p.m.)	5% CAGR
Personal cost	-2%	-0.5%
IT Equipment CAPEX	-50%	

Table 6: Impact of FI on value and growth

Ratios (10y or to infinity)	Unit	w/o FI	with FI	Delta	Comment
Sales	k€	3.336	3.625	9%	plus 8,7% , better quality
Production (Wheat + Barley)	dt	139.950	141.081	0.8%	Better quality on cost of quantity
Simple ROI	%	45%	58%	28%	EBIT/ Cost (excluding CAPEX)
Payback	Years/month	6.2	5.3		On NPV
NPV	k€	208	362	74%	Discounted cumulated CF

IRR	%	15.5%	19.3%	25%	Discount rate in the cases is 9%
MVA	k€	306	459	50%	Discounted added value
TCO	k€	3 761	3 749	-0.3%	Total cost of ownership
Value of investment	k€	1 419	1 841	30%	total "sales price“ of the farm

Table 7: Financial benefit of FI

Table 7 shows, that even a minor decrease in costs in parallel with a moderate increase in earnings which is made possible by an improved response to the market requirements causes a significant improvement of the economic outcome of the farm.

3.2 Environmental aspects

The most important factors for an individual site are sun, air, soil and water. Of the four, water and soil quality and quantity are most amenable to human intervention through time and labour.

Although air and sunlight are available everywhere on Earth, crops and plants also depend on soil nutrients and the availability of water. When farmers grow and harvest crops/plants, they remove some of these nutrients from the soil. Smart farming depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas (used in converting atmospheric nitrogen into synthetic fertilizer), or mineral ores (e.g., phosphate).

The Future Internet based practices in farming can significantly reduce the amount of nutrient and other crop inputs used while boosting yields. Farmers thus obtain a return on their investment by saving on phytosanitary and fertilizer costs. The second, larger-scale benefit of targeting inputs—in spatial, temporal and quantitative terms—concerns environmental impacts. Applying the right amount of inputs in the right place and at the right time causes benefits in crops, plants, soils and groundwater, and thus the entire crop cycle. The agriculture in the future seeks to assure a continued supply of food within the ecological, economic and social limits required to sustain production in the long term.

Improvement in environmental quality may come simultaneously with improvements in farm profitability. By applying inputs in the exact, needed dosage on the exact areas needed, costs can be decreased, profits improved, waste eliminated, and the potential for environmental damage reduced.

Irrigation

In some areas, sufficient rainfall is available for crop and plant growth, but many other areas require irrigation. For irrigation systems to be sustainable they require proper management (to avoid salinization) and must not use more water from their source than is naturally replenished, otherwise the water source becomes, in effect, a non-renewable resource. Improvements in water well drilling technology and submersible pumps combined with the development of drip irrigation and low pressure pivots have made it possible to regularly achieve high crop yields where reliance on rainfall alone previously made this level of success unpredictable. And it is necessary to develop smart irrigation system in plant growing (such as in greenhouses) to use the right amount of water in the right places.

Soil erosion is fast becoming one of the world’s greatest problems. Without efforts to improve soil management practices, the availability of arable soil will become increasingly problematic.

Some Soil Management techniques: No-till farming, key line design, growing wind breaks to hold the soil, incorporating organic matter back into fields, stop using chemical fertilizers (which contain salt)and protecting soil from water runoff.

Site-specific pesticide application – Smart spraying in the fields and in the greenhouse

It is difficult to assess the exact influence of patch spraying with herbicides on the very local micro-flora and wild life habitats. The reduction of herbicides and pesticides will have a positive environmental impact on water recipients, wild life habitats and food quality in general. Smart spraying can reduce the application of chemicals compared to conventional spraying in cereals. Consequently, the micro-habitats in the field ecosystem will be less stressed from unnatural disturbances, which is a benefit for the biodiversity. It is however less certain whether insecticides and fungicides can be applied spatially in cereals since it is difficult to detect fungi and insects in a field environment.

The total amount of fertilizer may not be reduced on a field basis but it will be reallocated from areas of low response to areas of high response. Another way in which the environmental benefit may be seen is the ability to specify in an integrated system, those areas where certain chemicals may not be applied at all or at lower rates. For example, setbacks from surface water and ground water inlets can be specified as no spray areas and the technology of smart farming would allow them to be avoided automatically as the farmer covered the rest of the field. This setback could certainly be done visually without this new technology, but the new technology complements farmers' interest in covering ground quickly while at the same time providing environmental benefits to themselves and the public.

Energy for Agriculture

Energy is used all the way down the food chain from farm to fork. In industrial agriculture, energy is used in on-farm mechanisation, food processing, storage, and transportation processes. A controlled traffic system with GPS and sensor technologies for the agricultural machines can be reduced the use of fuels. In controlled traffic mainly fuel use could be reduced with fewer overlaps when combining, harrowing, ploughing, seeding and general improved logistics and better utilisation of the farm vehicles during tillage. It might also be possible to reduce soil compaction and reduce the pressure on wild life habitats due to gentle movements on the field. Moreover, it is possible to localise drainage areas and arable farm areas close to water recipients and other vulnerable locations. There are other benefits that can be obtained from applying controlled traffic farming-technologies:

Soil health and earthworm activity may be improved due to "non-wheeled" treatments It may also improve habitat conditions of macro- and micro-fauna in the soil. This again can improve soil health and result in higher yield rates. Soil protection levels may increase due to broader plant cover density and higher organic matter contents. Biodiversity and microbial activity may also increase. Soil compaction may be further reduced through improved plant cover density and evolvement of the root-system, which is more efficient than mechanical cultivation by tillage.

Agriculture has strong impact to the landscape and ecological diversity. Especially arable farming and grazing of animals operate on large land areas, in close connection to surrounding natural ecosystems. Agricultural areas can be seen as special agro-ecosystems interacting with pure natural ecosystems. The biodiversity of the agro-ecosystems can be intentionally or unintentionally poor like conventional cereal monoculture areas, or then very rich and unique like organic grazing lands with diversity of herbs, insects and birds. Agriculture affects the environment and natural ecosystems in two ways; 1) by using natural resources like land, water, minerals, fossil fuel and 2) by releasing emissions outside the farming system like greenhouse gases, nutrients, chemicals, energy (soil compaction), organic and inorganic material waste. The control of farming processes has direct impact on both effects. Improved utilisation of inputs by the process mechanisms and precise *dosage* and *timing* of inputs according to process needs leads to decrease in emissions from the process. Biological processes like plant or animal growth, milk, eggs and fruit formation are the base of the production. Controlling of process environment parameters like temperature, humidity, quality of air components (O_2, CO_2, CH_4, N_2) and nutrients are the central tasks of farming. Protecting the cultivated population from harmful competition of other species like microbes causing diseases, insects or weeds in plan production, and favouring advantageous ones are also aims of process control in agriculture.

The control of biological processes in farming involves increasingly technical processes in the modern agriculture to establish and nurse the biological process, to harvest the resulting bio-products and to *transfer* materials; inputs and end-products. ICT has an important in role improving the process control mechanisms to avoid causing emissions and waste in agriculture.

3.2.1 Key features of Smart Farming pilots to decrease environmental impact

3.2.1.1 Greenhouse pilot

FI based greenhouse control system provides farmer with on-line monitoring data (IoT) about the plant status, alarms concerning the threat of imperfect growing circumstances like water or nutrient deficiency, disease occurrence, or coming weather changes like decrease in temperature or approaching storm. This assists farmer to react in time and in a correct way to meet the plants' needs and to avoid unnecessary use of inputs and otherwise caused damages. Easy access to e-agriculturist services enables decision support in complex decision making situation, especially when there is need to make compromises to original farming plan due to unexceptional sudden events, like disease flare or unfavourable outdoor weather conditions. This prevents unnecessary environmental emissions and increase farmers awareness and skills to handle similar situations in the future work. Data analyzers monitor and check quality of sensor data continuously and Notifier warns farmer about the faulty sensors or errors in from the data conducted information. This prevents the control system unintentionally to feed the system with incorrect or excessive dose of inputs, which may cause emissions to the environment. Furthermore, when monitoring the growing status of the plants, it is possible with the smart control of input parameters like growing temperature to adjust the timing of yield ripening to meet the demand in the market. This lowers the risk of over production and thus decreases the waste.

3.2.1.2 Spraying pilot

Compared to greenhouse case, the spraying pilot take place in the open space, field. The climate factors cannot be controlled, and thus the nursing of plants has to be adapted to natural climate conditions. Smart spraying involves disease alarms to notify the farmer when it is proper time and necessary to carry out spraying, and in which fields. This assists farmers to avoid unnecessary use of chemicals and thus minimise risk of chemical emissions to the environment. The arable farming covers usually large field areas, which means that cultivation actions involve mobile machinery, traffic and logistics as important production components. Smart scheduling of tasks of different of different fields and involved machinery, workers and material transport improves timing of spraying and also minimize needed amount of spraying chemicals and fuels. The spraying work unit receives updated weather information and is capable to adjust spraying settings of the sprayer according to the weather conditions, e.g. to avoid wind drifting of chemicals. Nowcast information of approaching rain is utilised to notify the driver to stop spraying early enough before rain to avoid chemical leaching to the environment. The precision spraying adapts the chemical use also to the spatial variation in the field. The dosage of disease protection chemicals follows the amount of biomass or spatial existence of certain disease. It is important that the applied dose is correct, since too high amount of chemicals increase the risk of emissions to the environment and too low amounts lead to chemical-resistant disease (also weed or insect) populations. In case of machine breakdown, the smart spraying system alarms the failure in the system. The machine breakdown service monitors the sprayer and its log data remotely, and assists on-line to quickly repair sprayer to continue the work in time with properly performing machinery to avoid incorrect dosage of chemicals. Use of spraying chemicals involves a lot of regulations due to food and environmental safety. On-line update of task plan in exceptional events, e.g. in case of changing chemicals on-the-fly, assists to perform the spraying task optimally and to avoid mistakes in complex decision making situation in the field. The farm manager is able to monitor remotely the spraying operation and optimise the fleet logistics to perform efficiently and environmental friendly way.

In the both pilots, a common feature is that locally available assisting services can be listed and purchased ad-hoc and start using them on-line via FMS. The systems also log process data in desired way. The collected data are used to increase the awareness of work processes and learning from the experience by both worker and farm manager. The gained knowledge is used to improve spraying performance and task planning for the next time. The logged data are further used to produce environment specific information about the end product, e.g. carbon footprint or chemical usage information.

3.3 Social aspects

The smart farming pilot developed around the arable farming demonstrated technical feasibility of those FI innovations and enablers developed in the FI programme. It appears also that it the Smart farming pilot could find support for FI-based farming concepts from the end-users so that the social feasibility could be demonstrated. The end-user feedback gained conveys the message that farmers are aware and concerned of the generic challenges of the food –chain, i.e. food safety, environment, ethical issues and cultural preferences, and that they see the possibilities of FI to tackle these challenges.

In both the smart spraying and the greenhouse pilots the project group was able to develop business models that could be found credible and acceptable by the end-users. Especially in the case of the smart spraying we were also able to articulate the concepts from the end user point of view and describe what the added value of the concept could be for farming.

It was found that the smart farming work process focuses on optimising safety and environmental goals with regard to efficiency of farming.

Safety of the product (food safety) was considered especially with regard to pesticide residues. In order to monitor this optimization goal the actor needs to pay attention to his/her pesticide usage and that the usage fulfils the set rules and norms.

Environmental values were also considered. Wind drift was found one of the most important goals of optimisation that relates to accounting environmental values. The criterion is observing the wind direction and velocity wile spraying. Environmental values were also portrayed when considering the carbon footprint goal. The criterion to observe by the actors is that fuel consumption is kept under set carbon dioxide limits.

Connected to better control of food safety and environmental challenges also the possibilities to improve the quality of products and development of new products, and markets were considered. The increased transparency of the food chain was considered a possibility also to demonstrate the quality and develop high brand products.

Reduction in work load was not the most dominant issue that the end-users considered when discussing the perspectives of FI-based technologies. Of course some increase in effectiveness of work and saving of work effort was anticipated but these prospects were, probably, not the most motivating aspect of the new technology. The possibilities of the Future Internet based technologies were connected with developing the agricultural domain and work, and the possibilities to learn and develop new competencies. These aspects appeared to have high relevance for the end-users.

Improved networking was one of the most relevant functionalities that FI-basic technologies can provide for farmers. Information sharing for creating professional and situation awareness and possibly sharing of work seamlessly by sub-contracting within the network would support farmers to operate their everyday tasks and increase satisfaction towards their work.

Tailored services according to the user needs ensure the usefulness of the service framework for all users despite their educational background. The markets should be aware of the user needs in the present (and local) markets and react the need by providing appropriate services.

3.4 Evolution path

The SmartFarming pilots target to be considered as an examples for the future developments of agricultural IT systems. The shift of services from local devices into the cloud requires an infrastructure which enables high data rates and storage space for a huge amount of data. In the following chapter we will analyse how SmartFarming and the FutureInternet are prepared to cope with various upcoming requirements in the future.

3.4.1 Extensibility

The requirements for agricultural software are continuously changing. This is caused by several factors: (i) Political regulations change both on a national level and on the EU level, e.g. due to the new Common Agricultural Policy. (ii) New crops like energy crops and new cultivation practices appear. (iii) The structure of farms changes: the average farm size is continuously increasing while smaller farms disappear.

The architecture both of the Greenhouse Pilot and the SmartSpraying Pilot has been designed in a way to allow the simple integration and collaboration of services developed for independent providers. This will provide a new market place like AppStore or the android market and enable a certified provider to release its application and gain revenue. In principle, this model enables a single developer who has a ground-shaking idea to implement it, integrate it in our framework and gain revenue upon its deployment. Thus the approach supports individual creativity and enables economic growth. It should be pointed out that in our case the main difference is that services are not simply downloaded to a smart phone and run independently but use common interfaces to share data (e.g., a farm's environmental conditions) and use common services (e.g., FMS controller) or GEs.

The Service FMS (Farm Management System) Framework provider is independent from underlying subservices and external services providers. Thus the SmartSpraying Service FMS Framework provides autonomy for underlying subservices, thereby encouraging companies to focus of providing better competitive service products for users. Furthermore, users are not limited to a single service but the framework also allows service composition, mash up, and tailoring of services from different providers (individual persons, small, medium and large companies) for the user.

A similar approach is realized for the hardware sector. The use of the FI-WARE IoT technology allows the installation and use of sensors and actuators in a simple plug-and-play way. The service oriented architecture provides a standardized manufacturer independent interface for the connection between installed equipment on one side and the manufacturers and maintenance service providers on the other side. A software module within the FMS analyses the received sensor data and performs fault identification. The operation of new equipment is therefore largely facilitated.

The adoption of new technologies and practices is supported by learning schemes. Since the collection of any information (from sensor's data, the recorded actions and their results) is automated, expert systems can improve their operation through learning schemes. This approach also takes advantage of networking data sources among each other, e.g. by integrating statements and assertions from public information sources. These learning schemes can be implemented using appropriate statistical analysis and data mining methods.

3.4.2 Flexibility

One of the key features of the SmartFarming framework is its flexibility. Dynamic device dependent services allow coping with changing technical conditions like the varying network connectivity.

In the frame of context aware networking, FI-WARE provides interfaces with the underlying network infrastructure. This has been taken into consideration to improve the performance of the farm management system. For example, a broken link to a farmer will be noticed by the system in order to organize when to transfer data to and from the farm. This will also allow a better understanding of a possible system's under-performance (e.g., due to a software defect or due to a network congestion). The system is designed to operate in an autonomous (i.e., self-x) way when possible. In other words, the system enables self-configuration, self-optimization and self-healing mechanisms using FI-WARE generic enablers (e.g., IoT, statistical analysis etc.) The system supports the autonomic operation of context aware machinery that is able to collect the necessary information, plan and execute a number of complex actions (e.g., tractors automating the planning and the execution of a spraying function even if problems are also encountered).

The farmer will be always notified in the most suitable device (e.g., mobile phone, tablet, laptop or desktop) through appropriate services (SMS, MMS, mail, web service etc.) and format (e.g., text, photos, HD video) since the system will be able to dynamically identify what is the device the farmer is currently using and what are the capabilities of this device. This will be achieved through the multi-device and multi-channel FI-WARE's access system.

3.4.3 Scalability

Most business activities in the agri-food chain are generating data that is immediately relevant for the workflow control as well as data that is relevant for medium to long-term documentation, reporting and planning. Especially the latter is relevant for future purpose and needs to be stored for being able to provide information along the chain and establish the baseline to prove evidence for trust generating initiatives.

Single and especially SME type organisations in the agri-food chain are generally not generating Big Data in ICT related terms. However, there are diverse organisations that are providing their services to diverse organisations in the chain. For example, in the EU27 there are about 13 million farms. These operations are connected to billions of objects taken into account the products to be forwarded.

At this moment, based on existing technologies, most information and related events are currently not handled by ICT systems. Data like pictures that are taken to recognise certain information (e.g. identification, quality, status) are even immediately deleted to avoid the handling of large amounts of data or the monitored events are highly limited as the ICT related capacities are lacking that could support forecasting, certification and refining the planning. Subsequently, the actors are currently not able to further exploit this information on the medium to long term.

Therefore, when talking about “big data”, the stakeholders are specifically addressing the FI-driven potentials that are expected to enable the tracking and processing of information in relation to hundreds or even thousands of events of billions of objects that are moving through the agri-food chain, while the monitored data is uniquely identified as well as combined with plain text information or documents and multi-media type of information that would provide the basis for further event processing, reasoning and even enabling business intelligence type of algorithms to better predict potential quality problems, logistics issues as well as to assess the trustworthiness of business partners.

The FP7 project “agriXchange” analysed the data exchange in agriculture exemplified by nine use cases and identified 24 interfaces where data are transferred between systems. This chapter investigates in detail what capacities are needed to handle this data.

The assumptions made are based on KTBL data on agricultural work processes in Germany [5]. These data give an average number of machine hours per area and year (h/ha) In order to have estimations that are more likely to be too high than to low, an average farm with medium yields on medium soils was taken as data model. These data are extrapolated for the EU27 [7]. However, data for specialised crop cultures were not considered. For Germany, the areas for these crops are comparatively small. No data are available for cultures which are important in some EU countries, e.g. citrus, olives, etc.

Culture	Machine working hours/ha	Area Germany [1000 ha]	Machine working hours Germany	Area EU27 [1000 ha]	Machine working hours EU27
Wheat	9.57	3,248	31,083,360	17,781	170,164,170
Rye	7.69	614	4,721,660	2,657	20,432,330
Winter barley	8.06	1,178	9,494,680	0	0
Spring barley	7.42	420	3,116,400	11,115	82,473,300
Oats	7.47	143	1,068,210	4,319	32,262,930
Triticale	7.76	383	2,972,080	0	0
Rapeseed	8.05	1,329	10,698,450	5,808	46,754,400
Sunflower	7.45	27	201,150	3,208	23,899,600
Peas	7.85	56	439,600	1,310	10,283,500
Field beans	7.43	17	126,310	0	0
Potatoes	33.22	259	8,603,980	2,087	69,330,140
Sugar bear	10.31	398	4,103,380	1,599	16,485,690
Corn (incl. Corn Cob Mix)	8.95	488	4,367,600	6,634	59,376,985
Silage maize	15.63	2,029	31,713,270	0	0
Field grass	20.36	397	8,082,920	6,986	142,234,960
Grassland	15.79	1,813	28,627,270	0	0
Meadows	18.93	2,630	49,785,900	19,848	375,715,068
Legumes (whole plant harvest)	20.36	264	5,375,040	0	0
			204,581,260		**1,049,413,073**

Table 8: Culture area and estimated working hours for crops

ISOBUS logs position, time stamp, and several other data items every second. Assuming ISOBUS logging is running all the time, and roughly assuming that a logged line of data per second is 1024 bytes, we thus generate 1024 byte/sec or 3,7 MB/hour.

For all machine working hours in Germany resp. the EU (see Table 8), arable farming would then generate 754 Tbyte (754*10^12 Byte) for Germany and 3.8 Petabyte (3,8 *10^15 Byte) for EU27 per year.

However, these figures dramatically increase when image data are also considered. Live data transmission of images would need a transfer rate of 2.3 Mbytes/sec (320*240 pixel *1 Byte* 30 frames /sec). So, if each tractor was equipped with a camera and streams its data into the cloud, this would generate 1.7 Exabyte (1.7 * 10^18 Byte) each year for Germany and 8.7 Exabyte (8.7*10^18 Byte) for the EU.

Considering the amount of data generated by the pilot greenhouses, the assumption is made that each greenhouse unit is equipped with 5 sensors, which in total generate 720 Kbyte per day, an IP camera streaming its data continuously (320*240 pixel *1 Byte* 30 frames /sec = 199 Gbyte per day) and a camera capturing the status of the greenhouse by taking 10 pictures a day (768 Kbyte per day). For all equipment running 24 hours a day and 365 days a year, this would result in 72 Tbyte per year for each greenhouse unit. The EU27 has about 149.574 ha greenhouses. The average size of a greenhouse unit is assumed to be 0.8 ha [6], so that the EU27 has an estimated number of 186.968 greenhouses units. This would result in 13.6 Exabyte per year (13.6*10^18 Byte).

These numbers show that the amount of sensor and status data can be easily handled by existing systems. However, the application of live stream cameras in greenhouse and on tractors generates data in a problematic dimension. Data management capacities have to be established accordingly. Alternatively, data have to be -pre-processed before sending into the cloud. This might also be necessary regarding restrictions in data transfer rates. The high data transfer rates and the large storage place required need new technologies to handle them. Such technologies are provided by FI-WARE thus avoiding current bottlenecks.

3.4.4 Portability

The pilots of the FMIS are based on a Service Oriented Architecture (SOA) which means that the functionalities are provided by services through platform independent and standardized interfaces. Both the pilots as well as the FI-WARE Generic Enablers are using RESTful service interfaces based on XML message exchange and HTTP protocol. Whenever it is possible standardized XML languages like agroXML, GML or ISO11783 taskfiles are used.

Regarding all modern programming languages both libraries and tools for XML processing and HTTP messaging are available. For that reason the FMS functionality can be easily integrated into other applications by implementing client logic for the service interfaces to be used. Furthermore third party functionalities can be easily integrated into the FMS by wrapping service interfaces around that functionalities. This is possible for the pilots but it has to be checked regarding the Generic Enablers.

Because of the fact that the pilots are based on open and widely used standards, which are well supported by most programming languages and platforms, there is no need to rely upon tools to a certain framework, what demonstrates the high impact and advantage of open architecture. If we take a deep look on the farm level layer we have to take into account the possibility of potential embedded systems that are integrated and using maybe higher level languages and modelling tools. Resource constrained embedded systems can be integrated into the service architecture through gateways. E.g., a display on a tractor which is a relatively powerful controller could serve as a service gateway that provides service interfaces to various deeply embedded systems on the tractor and its implement. Alternatively the manufacturers of tractors and implements which are already collecting data remotely from machines and also provide remote access to these machines can also grant access to this data and functions to third party applications by service interfaces.

Same functions can be amplified for sensors and actuators as well the Internet of Things (IoT) Service Enablement GE can also be used for the same.

3.5 Responsibilities and organization

The developed Smart farming pilot including a demonstration of arable farming (farming service and spraying) and greenhouse, both including initial demonstrations for user interfaces, have gained positive responses from the end-users who have been involved with the design and development face. In the further development of the Smart farming concept the end-user involvement should be continued and developed further. So far both the Finnish and Greek developers have utilised design work-shopping within which the concepts created have been discussed and developed further with a small number of farmers. Typically, the focus of the development has been focused on particular information intensive work-processes and farming tasks. The inclusion of the Smart service framework concept elaborated the work process-oriented development. It became also clear, that the perspective of the future service increased the interest of end-users towards the FI-based farming and raised even more positive expectations among the end-users. .

The functional parts of the Spraying pilot are illustrated in Figure 11. The functional parts, corresponding system parts and suggestions for their provider organisations in the Spraying pilot are listed in Table 9. All actors of the system have to identify themselves with the Service Oriented Architecture. The pilot is building on existing system parts, where existing machinery, devise and sensor providers must adopt Internet of Things technologies in their system interfaces. Existing service providers have to register themselves to the Marketplace and share open system interfaces so that the Global Customer Platform services are able to forward the specifications further to the combining Service Framework. The Marketplace and the Global Customer Platform functionalities are based on FI-WARE GEs and they are new business for existing service providers like telecompanies or specific Third Trusted Parties, or for new type of enterprises. Existing portal type services providers could act take a role of a Service Framework provider.

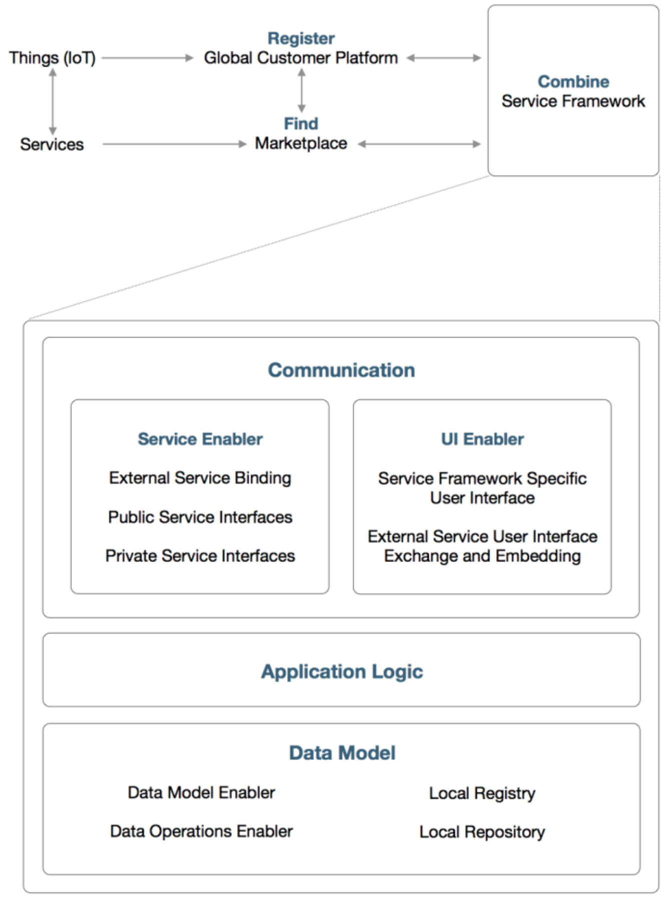


Figure 11: Functional parts of the spraying pilot

Functional part	System part	Provider
IoT	Sprayer Tractor Weather stations in the area On-Board weather station	Machine manufacturers Sensor providers
Services	FMIS Weather information Disease alarm Machine breakdown service Communication Monitoring service Data storage	FMIS software provider Weather station network service provider Meteorological institute Advisory service provider Machine manufacturer Tele company Network provider Software provider Machine manufacturer Software provider
GCP	Service registering and e-business	Tele companies, Third Trusted Party
Marketplace	Service gallery	Advisory organisations
Service Framework	User oriented service integration	System integrating service providers

Table 9: The functional parts, corresponding system parts and suggestions for their provider organisations in the Spraying pilot.

Similar to the Smart Spraying pilot, the Greenhouse Management prototype builds on top of available off-the-shelve components and extends them with Future Internet capabilities. The main objective of the Greenhouse Management prototype is a Future Internet compliant framework which will be able to take into account real data (e.g. weather data) from sensors and provide it to a Farm Management System (FMS) in order to take smart decisions regarding actions that need to be done and will eventually lead to the increase of the farm's productivity. External services have access to the real data collected and produce results related to smart planning of farming actions. Notifications and alerts about the current situation and actions are forwarded to the farmer. In this way, a farmer achieves having a complete surveillance of his farm.

At a conceptual level, a farmer deploys sensors in his farm which exploit the IoT functionalities and communicate with the local part of an FMIS. In turn, the latter transmits all information to its cloud counterpart. The information is available to third party trusted providers, machine manufactures and in general all system actors for further exploitation. A potential exploitation lays in the provision of value added services. The farmer is able to access a Marketplace where independent service providers (software developers, regulators etc.) provide services. The services exploit the available data and offer enhanced information to the end user. This description is summarized in Table 10.

The transition from the Functional Part to the System Deployment through proper deployment and extension of the available System Parts can be found in D200.3 [13] and D500.5.2 [12]

Functional part	System part	Provider
IoT	Sensors deployed in the Greenhouse	Manufacturers (Libelium)
Services	Monitoring Service Advisory Service Weather Service Connectivity Service Hardware Monitoring Service	Manufacturer or third party trusted developers Regulator (OPEKEPE) Meteorological Institute Built-in service Manufacturer or third party

	Consultancy Service	trusted developers Third party trusted developers
Marketplace	Service gallery	Advisory organisations, Software Providers
Greenhouse/Farm Controller	FMS Controller	FMIS software provider, Cloud Computing Provider

Table 10: The functional parts, corresponding system parts and suggestions for their provider organisations in the Greenhouse Pilot

In the next phase of development it would be necessary to develop the design concept at least in three respects: The focus of the pilot development would have to be on an ICT-ecology that covers the main challenges and functions of the food chain. Second, it is evident that changes are also required in the methodology of end-user participation. A living lab type of development environment needs to be created, which includes both a technical infrastructure and the social forms of end-user participation. To the latter belongs also a methodology and tool-kit of interacting with the end-users and collecting responses and results of their inputs. The third is to develop a conceptual prototype that showcases how the Smart Farming concept should be considered in the light of a constant change in the concept of operations and the role of farming activity in an ICT-based society. It would be very important to involve the policy, government and regulatory aspects into the development work. Even more important would be to consider how the current economic structures and institutions should respond to the changes required in the entire value chain

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5 Appendix A

Benchmarking of the Greenhouse pilot has commenced. An indicative list of benchmarking indicators appears in the following list. It should be noted that the list is not exhaustive. More indicators will be added as the process matures while others will be further detailed.

1. Quality indicators

- Product life time (how long before you need to fix something or upgrade)
- User acceptance
- User friendliness
- Quality of notifications (compared to the notifications sent by other systems or human intuition/perception)
    - True positives rate
    - True negatives rate
    - False positives rate
    - False negatives rate

2. Time indicators

- Time for deployment
- Learning curve (time required to learn the platform)
- Response time (applied to all individual test cases, e.g. time for notification to arrive, time for alert to be fired, time for implementation of an action, time for identification of an error etc)
- Time for investor to break even
- Time for firmware upgrade

3. Cost indicators

- Deployment cost
- Maintenance cost
- Other associated costs (e.g. network, electricity etc)
- Flexibility of charging model
- Update/Upgrade cost
- Indirect costs induced by Quality indicators

As far as quality indicators are concerned, the product life time depends on the software part and the sensor network part. Issues with software can be resolved very quickly, while hardware related faults are more time consuming since they require physical access. Battery is not an issue due to the use of solar panels. Therefore, the only parameter left is the reliability of the sensors which declines over time. According to the supplier's factsheet, sensors should be replaced after a period of approximately 12 months. According to these facts, product life time indicator is quantified as follow:

- Product Life Time
    a. Software: Infinite, thanks to the over-the-air software/firmware download
    b. Battery: Infinite power supply, due to the use of solar panels
    c. Hardware: 12 months guarantee

Moreover, according to a large-scale questionnaire-based research that took place, user acceptance rate is high; more than 70% of the respondents found the application very useful and are willing to try it in their own greenhouses. User friendliness is at an equally high rate as well, with 70% of the respondents finding the user interface easy, understandable and pleasant.

- User Acceptance rate: 70%

- User Friendliness rate: 70% found the system easy, understandable and pleasant

The deployment of the actual system in a greenhouse includes the PC installation in the farmer's premises, the configuration of the local network, and the installation of the sensor nodes. All these operations (depending of course on the size of the installation) take up to one working day. A significant added value of this approach is that no further interactions are required with expert personnel. Firmware and software updates can take place remotely (10' per update) which is a significant advantage when compared to the monolithic approach of the current commercial greenhouse management systems.

When the system is up-and-running, the farmer resides on it for notifications and alerts regarding the progress of its crop. Based on hands-on experimentation we identified that the mean time for a notification or an alert to be sent is 5 seconds.

To sum up, time requirements appear in the following list:

- Time for deployment: Maximum 8 hours
- Response time
    - Time for notification to arrive: 5 seconds
    - Time for alert to be fired: 5 seconds
    - Time for implementation of an action: immediate
    - Time for identification of an error: 5 seconds (software manages an error similarly to notifications/alerts)
- Time for firmware upgrade: 10'

Finally, the cost of deploying the system can be calculated by taking into account the following factors: number and type of sensors, person days, and PC cost. There are a number o possible configurations stemming from the above parameters, with various costs.

As far as the PC is concerned, a medium capabilities PC costs around €200. However, one could use very cheap special types of computers such as raspberry Pi [8], starting from €20, to host the cloud proxy. Furthermore, if the farmer wishes to have a GUI on the cloud proxy, he will need a monitor, starting from €50.

The cost related to the WSN hardware varies depending from the target application and the desired involvement in sensor hardware integration. The following analysis is based on indicative prices and the assumption that high quality sensors will be used. A WSN node can be divided into three components:

- **The platform**: The platform consists of the board, battery, solar panel (optional) and a plastic case that protects node components in harsh environments. Libelium [9] offers a sensor network platform characterized by easy sensor integration and convenient software libraries for the code running on the node. However, its platform (including a solar panel) costs €385. This cost can be cut down if an Arduino board (€25) is used. Adding an solar module and a 1100mAh battery (50 €), along with a plastic case (€16) the Arduino platform sums up to €91. The cost can be reduced further with the design of a custom board targeted at a specific application within the agricultural sector. This board can have only the necessary electronic components to accommodate just the sensors required, leading to simpler design with higher energy efficiency. At an estimated price of €15, adding a 3W solar panel (15), a 1000mAh battery (€6), and a plastic case (€16), the custom platform sums to €52.

- **Wireless connectivity**: There are several options here as well, perhaps the most widespread solution being the xbee Zigbee module, with a price depending on the desired range. 2mW output power with maximum range of 120m costs €20, while 50 mW output power can reach 1600m with a price of €38. In addition, GPRS modules can be used, rendering the local PC unnecessary, as the data will be forwarded directly to Cloud FMS Controller. GPRS modules cost around €70, and a 3G/GPRS data plan costs €25 for 5GB/month. Assuming that a node sends its measurements every minute, and the data it needs to send is 200 bytes, it will send 8MB/month. So, with €25/month, a farmer can have up to 625 GPRS nodes sending measurements every minute.

- **Measurements & actuation capabilities**: There are many parameters that can be measured inside a greenhouse. Indicative sensor types and values include soil moisture measurement (€30), temperature (€2), relative humidity (€20), CO2 (€40), PH kit (€80), Electrical conductivity kit (€120). As PH and electrical conductivity require a challenging integration (in terms of technical requirements), Atlas Scientific [11] provides kits (electronic board and a sensor) which greatly simplifies the integration process. Moreover, for actuation purposes, linear actuators used to open greenhouse windows can be purchased starting from €100 and solenoid valves for watering control start from €30.

The installation and configuration of such a system (5 sensor nodes, 3 with temperature sensors, relative humidity, soil moisture, 1 with CO2, PH, EC and 1 with temperature sensor located outside the greenhouse, all with solar panels and a low-end PC), in a greenhouse of 10000m^2 requires 5 hours. Taking into consideration all the above, assuming that a company charges approximately 40 euros/hour the total cost of deployment ranges between 1000 and 3000 euros.

To sum up:

- Deployment cost: Between 1000 and 3000 Euros
- Maintenance cost: Replacement of sensors. Depends on how many nodes and sensors are used (per sensor node), once a year should ensure reliable measurements.
- Update/Upgrade cost: Firmware/Software upgrade is free. Depends on how many nodes and sensors used (per sensor node), once a year should ensure reliable measurements.

We compared our system performance against MACQU [10]. The obtained results for the same metrics appear in the following list

- Product Life Time
    a. Software: Not applicable
    b. Battery: Not applicable
    c. Hardware: For hydroponics management nodes upgrades are necessary every 5 years and withdraw at 9-10 years. Climate controllers last more than 10 years but sensors must be changed every 2-4 years
- Time for deployment: Deployment of an installation with off-the-shelf components takes 2 days.
- Response time
    a. Time for notification to arrive: few minutes (through SMS service)
    b. Time for alert to be fired: commands from mobile
    c. Time for implementation of an action: Immediate (scale of seconds)
    d. Time for identification of an error: few minutes (includes diagnostics, 1 second for local processing and SMS transmission, treated similarly to notifications and alerts)
- Time for firmware upgrade: Upgrade is performed every 4-5 years
- Deployment cost: A climate system with 5-6 sensors and a weather station costs €4000 and additional €1000 are required for installation, reaching a total cost of€5000. Hydroponics machines range from €3000 to €10500.
- Maintenance cost: €300/year

- Update/Upgrade cost: software upgrade is free. Hardware upgrade every 4-5 years at the price of €500-€1000

Initial results stemming from this effort indicate that the developed prototype can achieve similar or marginally better behaviour when compared to commercial systems while in parallel maintain significantly lower prize and enjoy high user acceptance rate.