AIOTI
ALLIANCE FOR INTERNET OF THINGS INNOVATION

Smart Farming and Food Safety Internet of Things Applications – Challenges for Large Scale Implementations

AIOTI WG06 – Smart Farming and Food Safety

2015

Executive Summary

Working Group 06 (WG06) is one of the vertically oriented WGs within the Alliance for Internet of Things Innovation (AIOTI. The scope of AIOTI WG06 covers the scenarios and use cases where IoT-based technologies, applications and services with high added value to the actors within the plant and animal products life cycle from farm to fork.

The purpose of this Report is to provide specific recommendations on the implementation of a Large Scale Pilot (LSP) on smart farming and food safety as it is described in the IoT Focus Area call of Horizon 2020 Work Programme for 2016-2017. This LSP is expected to be an important instrument that will foster experimentation, replication and real-world deployment of IoT technologies in the European agri-food domain, while contributing to their interoperability and future market adoption.

The recommendations in this Report contain the views gathered between June and October 2015 from a large, multidisciplinary group of stakeholders and experts representing both the demand side (agri-food sector) and the supply side (providers of IoT technologies and services). These recommendations intend to be informative—by no means prescriptive— tool, and reflect only the views of the contributing experts listed herein, not that of the European Commission.

In section 2 of this Report we offer a mapping of previous initiatives aligned with the scope of the LSP, and provide specific recommendations and practical requirements arising from the demand side. Section 3 offers a mapping of available technologies and standards, and provides recommendations on technology dimension, where interoperability and replicability are highlighted as key elements. Section 4 focuses specifically on business models user acceptance, two crucial aspects that the LSP needs to address. Finally, Section 5 deals with general aspects of the LSP such as governance, cooperation among stakeholders and sustainability.

The Reader must be aware of the reports issued by other AIOTI WGs, which complement and enrich the recommendations contained in this Report. In particular, the Reader is referred to the recommendations issued by WG02 (Innovation ecosystems), WG03 (IoT standardisation) and WG04 (Policy issues). Additional complementarities exist with WG07 (Wearables) and WG10 (Smart environment – smart water management).

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1 Scope and focus of the WG

1.1 Vision

The use of innovative tools based on digital technologies in farming is expected to bring a number of benefits, such as increased productivity, increased profitability, and reduced environmental footprint, just to name a few. The use of digital technologies facilitating a higher productivity is recommended by the Food and Agricultural Organisation of the UN (FAO), as the associated increase in productivity can help reduce the *food security risk* faced in some regions of the world. If we focus on the European case, where food security is not a major concern, digital technologies have the potential of helping European farmers face other important challenges that are more specific to Europe, such as profitability, environmental footprint and sustainability of their exploitations and businesses.

By *smart farming* we understand the application of data gathering (edge intelligence), data processing, data analysis and automation technologies on the overall value chain, that jointly orchestrated allow operation and management improvement (analytics) of a farm with respect to standard operations (near real time) and re-use of these data (animal-plant-soil) in improved chain transparency (food safety) and chain optimization (smart data). Such capabilities will be necessarily supported by Internet of Things (IoT) technologies.

From the farmer's point of view, smart farming should provide the farmer with added value in the form of better decision making or more efficient exploitation operations and management. In this sense, smart farming is strongly related, but not limited, to the concepts of *Precision Agriculture* and *Precision Livestock Farming*. Farming modalities may include the production of vegetables, cattle (including dairy production) and others. Smart farming applications do not target only large, conventional farming exploitations, but could also be new levers to boost other common or growing trends in agricultural exploitations, such as family farming (small or complex spaces, specific cultures and/or cattle, preservation of high quality or peculiar varieties,…), *organic farming*, and enhance a very respectful and transparent farming accordingly to European consumer, society and market consciousness. Smart farming can also provide great benefits in terms of environmental issues, for example, through more efficient use of water, or optimisation of treatments.

The term *food safety* refers to the awareness, prevention and risk-based measures of foodborne illnesses, from food production to consumption.[1] Consumers' demands are currently the main drivers encouraging food industries to produce healthier and safe food products that being at their highest possible quality specifications. The challenge is that transparency of food safety should become data-driven and near real-time so that new applications and chain cooperation can lead to a more dynamic and responsive food production network. This terminology includes:

- "Food loss", which refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before reaching the consumer. Food loss typically occurs at the production, storage, processing and distribution stages of the food value chain, and is the unintended result of agricultural processes or technical limitations in storage, infrastructure, packaging and/or marketing. [1]
- "Food waste", which refers to food that is of good quality and fit for consumption, but does not get consumed because it is discarded – either before or after it spoils. Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain, and is the result of negligence or a conscious decision to throw food away. [1]

The scope of AIOTI WG06 covers the research, development, testing and implementation of IoT-based technologies, applications and services with high (commercial) added value to the domains of smart farming and food safety. AIOTI WG06 will also contribute to spread awareness of the benefits facilitated

[1] AIOTI WG06 deals with *food safety* as described above, and not with *food security*, which rather relates to ensuring that all the population has access to sufficient food and nutrients.

by the IoT, its technologies, ecosystem and infrastructure.

The vision of AIOTI WG06 is to become the key meeting point of EU-based stakeholders interested in developing and exploiting the benefits of the IoT (technologies, ecosystem and infrastructure) in the domains of smart farming based on food production and food safety. AIOTI WG06 will bring together European ICT technology and service providers with stakeholders of the ‘from farm to fork’ chain, such as European farmers, European Research and Education and other stakeholders, NGO’s and governmental bodies, to foster the generation of a future market of commercially viable IoT-based solutions tailored to the needs of the European agri-food sector. Moreover, AIOTI WG06 understands the importance to consider the international dimension not only at European level, looking also at trends and opportunities arising worldwide.

Within AIOTI, WG06 foresees synergies and cooperation with some of the vertical WGs of AIOTI such as WG05 (Smart living environment and ageing well), WG07 (Wearables), WG10 (Smart environment –smart water management), WG11 (Smart manufacturing), as well as with the horizontal WGs (WG01: IERC, WG02: Innovation Ecosystems, WG03: IoT Standardization, and WG04: Policy Issues).

1.2 Objectives

Globally, AIOTI WG06 on Smart Farming and Food Safety aims to identify the main challenges and opportunities for IoT-based solutions facing these domains while stakes the main involved players. Furthermore, the WG06 aims to provide recommendations on how a Large Scale Pilot (LSP) could demonstrate the benefits provided by such solutions within a short-term time frame (18-36 months). This includes providing insights into a manifold of dimensions that are relevant for medium-term market implementation, such as economic conditions, technical feasibility, farmer adoption, industrial value for key players, consumers and society expectations, scalability of the solutions, just to name a few.

General objectives of AIOTI WG06 are stated in the table below.

Table 1.1: Objectives of AIOTI WG06 -2015

Number	*Description of the objective*	*Expected completion*
1	Build a community (or ecosystem) of active European stakeholders interested in research, development, testing and implementation of technology, infrastructure and applications of IoT for farming and food safety. Target: 30+ EU-based companies	Q3/Q4 2015
2	Deliver a report with recommendations towards the implementation of a Large Scale Pilot on Smart Farming and Food Safety in Europe.	Q4 2015
3	To identify, thanks to a multidisciplinary participation, the trends and disruptions farming and food production will face in the near future.	Q4 2015
4	Identify the main benefits that IoT can bring into the European agri-food sector and identify the business models and innovation potential in the different sub-sectors in order to make solutions interested to be bought by the industry.	Q4 2015/ Q1 2016
5	Identify the main disruptive IoT-based solutions that could have game-changing effects in the agri-food market chain.	Q4 2015/ Q1 2016

These objectives are aligned with economic challenges related to the European Union:

- Food security issues: the FAO (Food and Agriculture Organization of the United Nations) predicts 9.6 billion people by 2050. Food production is assumed to increase by 70% by 2050, and so that security aspect must be reinforce to ensure quality of the food in all steps of the chain.

- Increasing environmental pressures: in particular limited availability of arable lands, water availability and quality (agriculture consumes 70% of the world's fresh water supply), climate change effects, and biodiversity loss.
- Economic issues: related to globalisation with greater inter-dependencies and more competitive pressure increasing the price volatility for agricultural products, which is strongly linked to developments in other commodity and energy markets.

In this sense, AIOTI WG06 is expected to contribute to the objectives of the European Union's Common Agricultural Policy 2014-2020.

Last but not least, WG06 objectives are focused on finding synergies between IoT applied over smart farming connected with smart agri-food industries. Some examples of these synergies could be:

1. **Focus on efficiencies across the 'from farm to fork' chain**: plant farming, livestock farming, food processing and food distribution are all parts of the value chain to deliver products to the final consumer. Roughly one third of the food produced in the world for human consumption every year (approximately 1.3 billion tonnes) gets lost or wasted [2]. Improved operations within each of step of the chain, plus improved IoT-enabled synergies between steps, e.g. between farmers and food processors (including, but not limited to dairy products), could improve the quality of the food and reduce costs. This objective is also linked to the WG11 smart manufacturing.
2. **Focus on (livestock) farming and environment**. The impact of the livestock sector is large. One large exploitation can house hundreds of thousands of pigs, chickens or cows, and produce vast amounts of manure, often generating the waste equivalent of a small city. One-third of our greenhouse gas emissions comes from agriculture [3]. Data driven smart farming can help to tackle these issues and contribute to a more sustainable production. The IoT can also unlock synergies in the distribution chain that will help further reduce the environmental impact of the agri-food chain.
3. **Focus on agriculture and water**: agriculture is the primary consumer of water, with irrigated agriculture currently accounting for 70 percent of world water withdrawals. Any solution to the water problem or pollution, thus requires serious improvements in agricultural water use, both in terms of irrigation efficiency and rainwater management:
    - roughly 45% of today's world food production uses 1.1 billion ha without any water management system (hence with low yields)
    - in comparison with 40% on 0.3 billion ha of irrigated land
    - and up to 15% on 0.1 billion ha equipped with a drainage system

    This objective is linked to the WG10 smart environment – smart water management.

1.3 Links to recommendations from other AIOTI WGs

The work in the AIOTI WG06 is reflecting the views in "IoT LSP Standard Framework Concepts", "IoT High Level Architecture (HLA)", and "Semantic interoperability for AIOTI LSPs" for IoT LSPs provided by WG03 and the content of the AIOTI Privacy Knowledge base developed by WG04.

The AIOTI WG03 has provided their views on the IoT standardisation that are covered in 3 documents: "IoT LSP Standard Framework Concepts", "IoT High Level Architecture (HLA)", "Semantic interoperability for AIOTI LSPs" for IoT LSPs. The documents describe and summarise the outcomes of the discussions within the AIOTI WG03 and reflect the interaction with the other AIOTI WGs.

The work of WG03 is seen as a reference for the AIOTI WGs in different domains in order to address the standardisation issues and to recommend the use of standard-based solutions for the deployment of IoT solutions in the LSPs. The documents offer an extensive overview of the IoT standardisation landscape and do not prescribe methods to achieve the implementation of the IoT solutions in different domains. This allows the stakeholders involved in the LSPs to be flexible and innovative in their use of the information, while assuring that they provide standard-based and interoperable IoT implementations. It is acknowledged that the LSPs will take a multitude of forms, are diverse in size, structure, and the scope and volume of services provided. The use of these documents provided by AIOTI WG03 as reference for the AIOTI WGs and the LSPs stakeholders will encourage flexibility and innovation while assuring the quality and interoperability of implementation of the different concepts and solutions in the LSPs.

These documents could be used as a checklist for stakeholders and include information about the IoT Standardisation Landscape, how each SDO and Open Source initiative maps its activities. This is extremely useful information for the stockholders of the LSPs that will work to develop standard-based, interoperable IoT solutions that can demonstrate compliance with specific standards or other standard-based IoT solutions.

The scope of AIOTI WG04, as per the AIOTI terms of reference, is to identify existing or potential market barriers that prevent the take-up of the Internet of Things in the context of the Digital Single Market, as well as from an Internal Market perspective, with a particular focus on trust, security, liability, privacy and net neutrality. In its policy document, WG4 highlights a number of key issues related to each of these areas. In so doing, WG04 also makes a number of recommendations to further inform both the policy debate and the activities of the Large Scale Pilots due to commence in 2016. WG4 also makes reference to other relevant stakeholders that are carrying out important activity in this field and which need to be linked to the work of WG04.

2 Mapping of existing initiatives in the relevant area of the WG

Agriculture and livestock are two strategic economic activities to society and are fundamental to help and keep many rural areas alive in Europe. These activities allow the development of such areas, contributing to the economic and social welfare of their population. Today's agriculture is productive and environmentally responsible. However, technological innovation in this sector will allow to maximize the efficiency of the activity while ensuring that food production delivers a good quality, reasonably priced result while complying with sustainable environmental criteria.

Agriculture consumes roughly 40% of the EU budget through direct subsidies, while only providing 1.5% of the output. Recent data gathered and analysed by Eurostat [4] reveals some figures about the importance of agriculture and farming in Europe’s economy:

- There are 12.2 million farms in Europe and 25 million people involved in agricultural production.
- Romania is the country with the highest percentage of agricultural holdings (more than 30%), while the next countries like Italy (~13%) Poland (~12%), Spain (~8) or Greece (~6%) have less than the half and the rest of European countries not even reach 5%. An interesting information is that about 10-20% of the holdings are dedicated to organic agriculture.
- Regarding the percentage of agricultural area utilized there are 174.1 million ha (hectares) which account for about 40% of the total land area. France is leading the list with a 16%, followed by Spain with a 14%. After that UK, Germany, Poland, Romania and Italy are between 5 and 10% and the rest of European countries are below 5%.
- **Animal farming.** Half of all EU farms have livestock. Some 90% of farmers with ruminant animals (cattle, sheep and goats) are specialist livestock producers [5]. Meat is a major source of protein and constitutes an important part of the European diet. EU policies in the meat sector are designed to encourage the production of safe, nutritious and affordable meats. Recent changes to the common agricultural policy (CAP) underline these aims. Policies are geared increasingly towards meeting the needs of consumers, livestock producers and the environment in a balanced way. They also work to improve the competitiveness of European agricultural products by ensuring that markets and consumers recognise animal welfare as an added value.
- **Livestock numbers** [6]. There have been considerable structural changes in EU livestock farming since the 1980s. Smallholders on mixed farms have gradually given way to larger-scale, specialised livestock holdings. In 2013, looking at EU Member States, Germany, Spain, France and the United Kingdom held the largest number of cattle. In Germany and Spain, these are mainly pigs (28.1 and 25.5 million heads respectively), in France bovines (19.1 million heads) and in the United Kingdom sheep (22.6 million heads) [5].

- The farm structure survey has allowed to classify European holdings per specialization. Next Figure shows the main distribution.

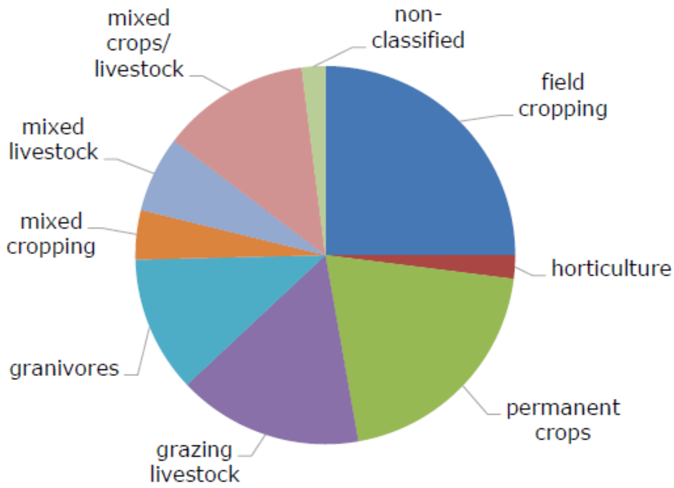
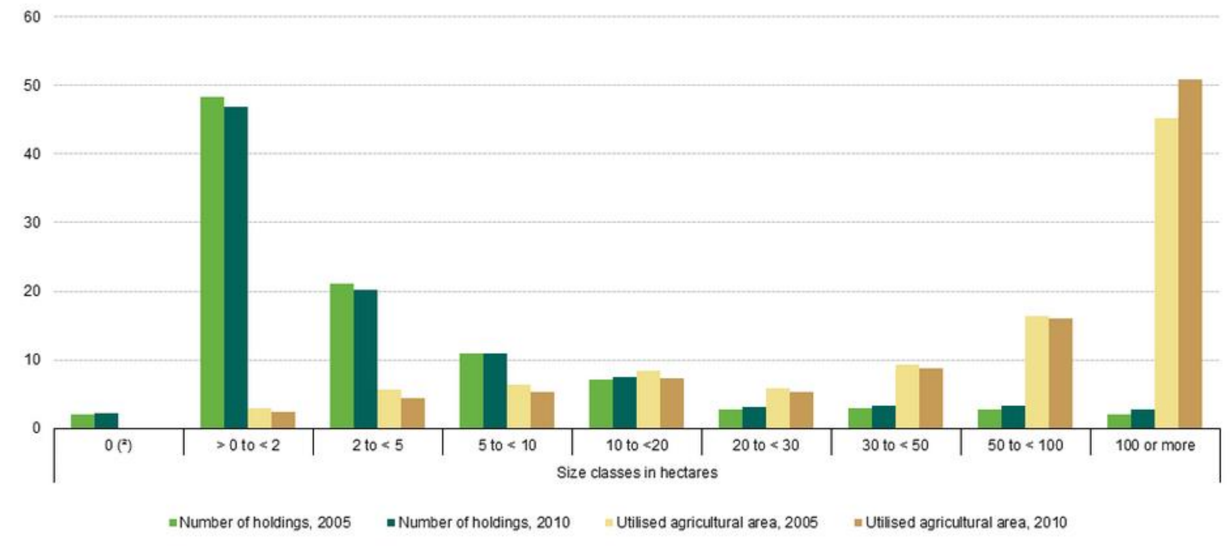


Figure 1: Specialisation of EU holdings

Furthermore, Eurostat analysis [7] in relation to the size of holdings reveals that the most common group are holdings with less than 2 ha (45%), whereas holdings larger than 10 ha represent the 25% of the total. In this sense, Europe faces a drawback in terms of scale with respect other regions of the world where average holding sizes are larger, and corporate farming is more extended.



(*) Shares may not sum to 100 % due to rounding.
(*) By definition the size class of farms with 0 hectares of utilised agricultural area has no area.
Source: Eurostat (online data code: ef_kvaareg)

Figure 2: distribution of holdings vs size

Organic farming sector has grown steadily in the EU over the last years, reaching a 5.4% of the total utilized agricultural area in 2011, according to Eurostat data. [8] Interestingly, the size of organic holdings (considering both 'certified' and 'in conversion to organic farming'), is more evenly distributed than in the non-organic case, with a 20% of exploitations between 10 and 20 ha being the most frequent class.

The statistical data provided above represents a very valuable input when it comes to define the target application cases for novel IoT-based solutions and services. According to the specialization of European holdings, we can observe a rich variety of cases potentially benefitting from the application of IoT. In terms of exploitation size, it may seem sensible not to focus intensely on larger holdings (less common), but rather on small and medium-sized ones given their higher statistical weight. The cooperation and aggregation of data across individual holdings can be seen as a way to compensate their smaller size, and this should be properly addressed from the IoT supply side. Furthermore, non-mainstream modalities, such as organic farming, should not be left out given their growing importance.

It is also important to remark that the application of IoT can bring important impact not only to highly technified exploitations, but also to farms with a medium and even lower degree of technology adoption. There is room for IoT-induced improvements in all cases, although the approach, application case and technology selection may vary for different degrees of technification.

The complexity of smart farming results from the diversity and heterogeneity of the ecosystem of players. The range of stakeholders in agriculture is broad, ranging from big business, finance, engineering, chemical companies, food retailers to industry associations and groupings through small suppliers of expertise in all the specialist areas of farming. Here we include technology providers (i.e. providers of wireless connectivity, sensors/actuators, edge devices, IoT solutions, decision support systems at the back office, data analytical systems, geomapping applications, smartphone apps, etc.), providers of agricultural equipment and machinery (tractors, autonomous equipment, farm buildings, etc.), providers of specialist products and inputs (e.g. seeds, feeds, and expertise in crop management and animal husbandry), end-users (i.e. farmers, farming associations and cooperatives), and influencers (e.g. stakeholders that set prices, influence the market into which farmers and growers sell their products).

When considering the food safety chain, additional actors must be included as well: food processors, transporters, wholesalers, retailers, and eventually, the consumers. This calls for the necessary involvement of all of them following a so-called *multi-actor approach* as it is defined in Section 2.2.

The cost of smart farming is high and farm offices collect vast quantities of information from crop yields, soil-mapping, fertiliser applications, weather data, machinery, and animal health, which are factors that influence farming and improve the productivity and costs.

Data collection, processing and interpretation are important building blocks of smart farming, whether the data comes from a soil sample, weather forecast, animal behaviour or a satellite correction signal for autonomous machinery. Data points collected can highlight both spatial, temporal and behaviour variability within a specific field analysis. Many factors can contribute to this variability. However, the understanding of their effect can be only measured and managed using statistical analysis of the data.

The farming applications are moving into the edge cloud, with the aim of delivering benefits in terms of data access, synchronisation, storage and even cost to the farmer. The rising use of smartphones and tablets on farms means that apps can be used to cache data offline until it can be synchronised since the data is distributed across several locations.

From the point of view of the supply side, the future adoption of IoT-based solutions and services within the ‘from farm to fork’ chain should have an important impact in terms of market opportunity for hardware providers, software providers, network/connectivity providers, and final service providers/integrators, which in turn, should translate in the generation of specific jobs in those different subsectors.

Based on the previous information, WG06 has identified the stakeholders of the value chain in smart farming and food safety in both sides – “from farm to fork” supply chain and IoT providers. This implies complex partnerships involving cross domain collaboration, with various stakeholders and partners bringing different skills and experience. Next image shows a first approximation that could cover the main roles involved

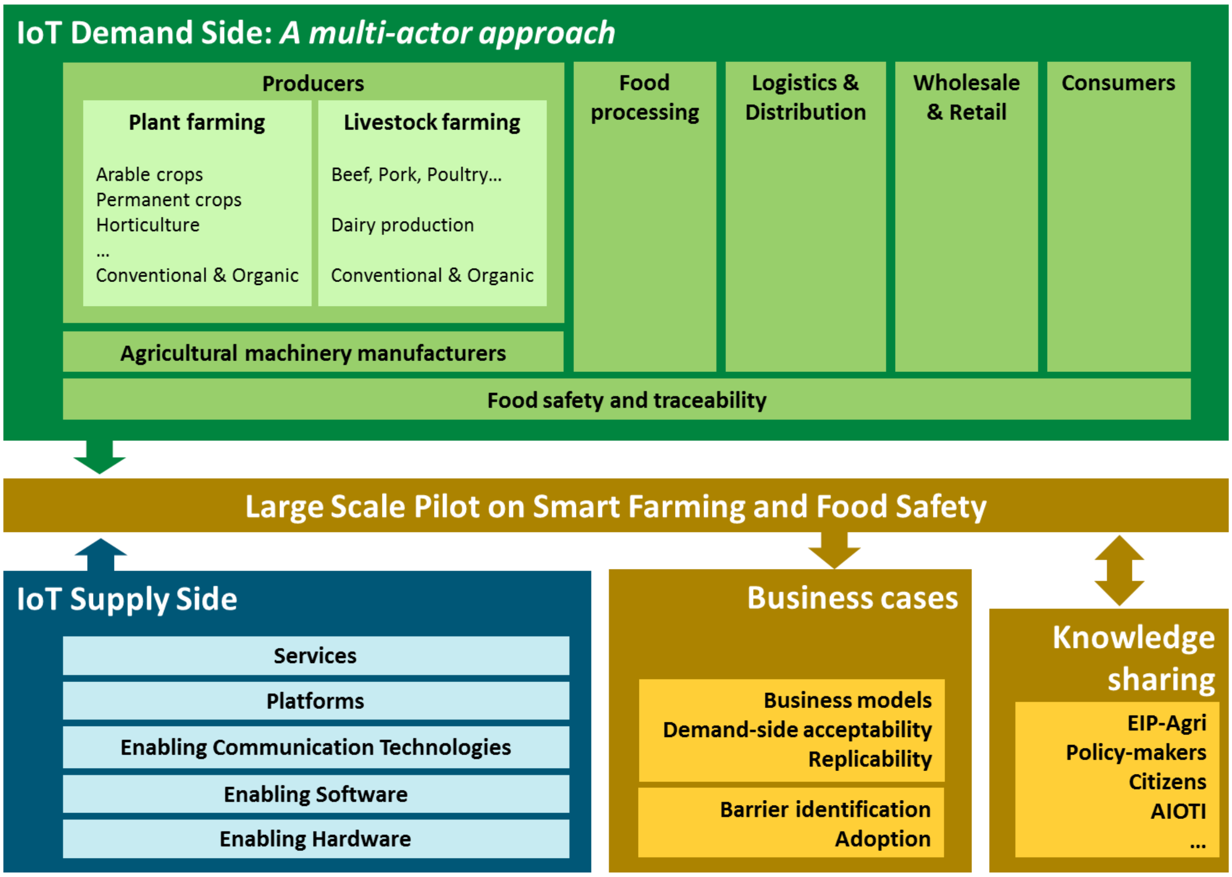


Figure 3: Smart farming and food safety stakeholders

2.1 Existing initiatives

Agriculture is traditionally considered chiefly as However, a conservative sector, where innovation takes place at a slower pace than in other sectors. Although this is changing over recent decades, it is fair to admit that innovation does not spread evenly across all farm classes and sizes, and all territories. However, Even if some of our food products still resemble those of a few hundred years ago and are not so much associated with innovation as new products in ICT, innovation has happened and on balance has contributed to social welfare. [9]

In recent years these innovation successes have generated discussions on the effectiveness of the innovation system in the agricultural and farming sectors. With plenty of food available and raising awareness of negative externalities (such as environmental and food safety issues) the future of the food system became an issue for broad political debate. For that reason, continuous innovation is necessary to make production more efficient and safer.

In relation to innovation in agriculture and farming, this section aims to introduce the reader to existing initiatives. They can be divided in 3 main types:

- **Partnerships and technology platforms**: A combination and integration of existing partial solutions including monitoring, control systems, collaborative platforms, best practices recommendations…is needed to share and add value to information.
- **Existing products and services**: Technological developments performed to cover and improve deficient aspects in the chain from Farm to Fork to obtain a more efficient process.
- **Projects**: Conducted individually or through a consortium at local/national/European or International level where different companies and research groups put together their expertise to generate and validate in (living) labs or via real scenarios solutions that can satisfy and enrich end users necessities.

In order to validate the potential success of new solutions or services, replicability or testing of the solution in different geographical environments should be considered. This is a common characteristic in already existing initiatives that enforces the impact that services created can achieve.

The Large Scale Pilot (LSP) in smart farming and food safety should carefully consider the results achieved in previous initiatives and projects targeted to the modernisation of the agricultural industry across Europe. The European Regional Development Fund provided €350 billion for developing rural areas in a broader sense and the results from these projects combined with the results from projects funded by national programmes to promote precision agriculture (i.e. UK - Engineering Solutions to enhance agri-food production supported by various government agencies, Germany - Farming 4.0, Netherlands – Smart Farming Project, Spain - Projects on irrigation management and viticulture, etc.) could form a basis for selecting the most innovative use cases and infrastructure.

The main topics covered by the analysed initiatives and some related examples are given here just as illustrative examples:

- Plant Farming:
  - Smart vineyard, a precision viticulture product for grape disease monitoring. SmartVineyard helps optimizing pesticide output by providing accurate data on diseases.
  - AgriXchange: agriXchange is a FP7 EU-funded CSA project to setup a network for developing a system for common data exchange in the agricultural sector.
  - FINISH is a Future Internet accelerator for food, perishable and logistics based on FIWARE technologies
  - sigAGROasesor, a life+ initiative in which a platform offering advanced services and DSS tools on WEB_GIS support for sustainable crop management in Spain. This Platform is devoted to farmers as well as technicians and managers of cooperatives and agribusinesses. This project is liaises also with LIFE AGROintegra, in which a collaborative pests monitoring a warning system is being implemented, in which different users (farmers, technicians etc) will share data for the common benefit.
- Livestock Farming:
  - Precision Livestock Farming (PLF): translate research results for PLF into a practical blueprint that benefits the animal, farmer, environment and consumer.
  - The EU funded ALL-SMART-PIGS: Demonstrate the viability of smart farming technologies in European pig farming. The project used a process of open innovation through a LivingLab to co-create smart farming applications ready for commercialisation on European pig farms.
  - The ICT-AGRI project PigWise monitored growth and welfare of fattening pigs by exploiting High Frequent Radio Frequency Identification (HF RFID), camera vision technologies and a middleware infrastructure, detecting at the same time pigs illness in early stages.
- Food processing
  - The European Technology Platform Food for Life
  - MUSETECH: integration of three High-End sensing technologies (Photoacoustic Spectroscopy, Quasi Imaging UV-Vis Spectrometry and Distributed Temperature Sensing) in a versatile Multi Sensor Device (MSD), for real-time monitoring (on-line or in-line) of multiple parameters associated with the quality and the chemical safety of raw and in-process materials.
- Logistics
  - FIspace: is a business-to-business (B2B) collaboration platform. It works like a social network, like LinkedIn or Facebook. Once registered, contacting affiliates is simple, secure and easy. Focused on agriculture
  - Finest: ICT platform for better supporting and optimizing the collaboration and integration within international transport and logistics business networks
- Retail
  - FoodLoop: Retailer Platform to tie grocer inventory system to consumer-facing mobile apps to provide real-time deals and personalized offers based on consumers' interests,

purchase history, and location

- Food safety/health/traceability:
  - Prometheus: On-line techniques to monitor reactions leading to contaminant formation, demonstration at industry level.
  - Optimalt: Optical inspection techniques to predict malt quality & safety
- Consumer
  - Ebbits project: consumer app for food traceability and rating
  - FRACTAL Fi-WARE accelerator
  - Agri-Food project: Smart food awareness to end user

New technology trends should also be considered, such as the use of Unmanned Aerial Vehicles (UAVs) for monitoring purposes of crops or even free-range livestock, or the application of wearable devices for livestock monitoring. Another emerging topic in recent years is related to the integration of ICT capabilities by agricultural machinery manufacturers (for example: John Deere, CNH Global, CLAAS and others) that is allowing the provision of an increasing number of value-added services to the farmer.

More details on additional initiatives, sectors and the corresponding working domains is given in Annex 1.

National initiatives within the EU

Agricultural and farming national strategic plans in Europe consider that generational renewal is a key factor influencing the modernisation and competitiveness of farms. A common trend is the emphasis on investments oriented to a more efficient management of resources [10], and the identified objectives of inducing the adoption of agricultural practices that are compatible with the conservation of natural resources (water, soil, biodiversity) and the improvement in energy efficiency. National support schemes will be addressed at small and medium-sized farms to enhance their production potential, which should in turn lead to higher value added. Due to the fragmentation of farms, the small scale of production and difficulties in adapting production to customer demand, there is a need for tools to address structural problems, like for example support farmers working together in producer groups and participation in quality schemes.

Some countries such as for example Spain [11], have strategic plans for organic agriculture, aiming at making ecologic production more accessible to the consumer through a more efficient production. In Poland [12], the modernisation efforts in the agricultural sector are oriented to streamlining the milk, pig and beef sectors, while maintaining a stable base of raw agricultural products for the food processing industry.

Initiatives outside Europe

Out of Europe, the agri-food sector is also benefitting from the changes introduced by IoT technologies. In the United States, where farmers (large farms) are financially strong enough to afford technological services, the market is more developed and adoption rates are high due to the trajectory observed. Giant companies such as Monsanto, DuPont, Bayer or Sygenta, are investing and begging for the smart farming and agriculture. For example, Monsanto recently purchased the Climate Corporation, a data analysis firm (nearly $1 billion). Monsanto also acquired Precision Planting in 2012, a high tech agricultural firm, and initiated a venture capital arm of the company in order to offer funding to tech start-ups. DuPont recently launched its Encirca farm services that help farmers make more informed crop planting decisions to improve their yields.

Special attention must be paid to opportunities arising in regions like Asia, Africa and Latin America, which are being affected by significant demographic changes and will need to take specific measures to ensure food security for a growing and increasingly urban population. New approaches towards smart farming in an urban context should, thus, be considered. The inclusion of innovative concepts around smart urban horticulture [13] may open the way to developing more sustainable solutions with the aim to ensure food security for a growing urban population and at the same time reduce emissions from transportation. This may contribute also to the possibility to enhance the market opportunities for innovative solutions "made in Europe".

China's effort to produce enough to feed its growing population has long been recognized. The country feeds over one-fifth of the world's population with only one-fifteenth of the world's arable land [14] , so achieving a larger and more efficient production are important policy objectives regarding food security and safety. One successful example is the "Agriculture Internet of Thing for Food Safety and Quality" project supported by the Ministry of Science and Technology, that started in 2011, and addressed solutions related to serialised numbers, product ID, life cycle tracking and tracing, and interoperability of different modules from different providers.

2.2 Relevant criteria for a LSP on Smart Farming and Food Safety

The LSP on smart farming and food safety should be seen as an important initiative that will deliver important evidence of the potential benefits of the application that the IoT can provide during the coming years. Therefore, the LSP should present a set of strong use cases that provide a relevant sample of the application fields in the domains of farming and food safety.

A well-defined use case should not only focus on the technological dimension (relevant to the IoT supply side) but also on other dimensions where the IoT demand side (end users) should have an important say (e.g., usability, business models, and interoperability, just to name a few) in order to properly address the pilot exercise and deliver comprehensive evidence and results.

The focus of this section is on providing a recommended set of high-level criteria that should be considered when designing and selecting the use-cases. This section is not meant to be prescriptive regarding the particular use-cases that should be part of the LSP. Despite this fact, and just for illustrating purposes, Annex 2 provides a list of potential use-cases that a number of AIOTI WG06 members from the demand side have identified already during the preparation of this document. Annex 2 should therefore by no means be taken as a prescription, but simply as a non-exhaustive list of possibilities.

Main relevant criteria LSP should cover are:

- **"From farm to fork"**. Agriculture and farming include several parties and stakeholders involved in the complex process of preparing and offering a product to the consumer. Most of the food consumed in the EU follows a process that goes from farms to manufacturers for subsequent processing or transformation and then to retailers or consumer services until reaching the final consumer. This journey from farm to fork generally passes through various wholesalers and involves other service providers such as transport and warehousing. Great importance is placed on the quality of food that is distributed to consumers (being from farms within the EU or from imports). Poor quality or safety assessment drives to large amounts of food are being presently wasted in European countries, being approximately equally distributed between producers/ supply chain, retailing and households. The LSP should seek to improve the efficiency and cost of complex process by which food reaches the consumer's table (production, processing, transport, preparation and consumption) through the use of systems and technologies that ensure more efficient process and the quality and safety from farm to fork chain. IoT strategy applied to this sector could cover not only the safety of food for human consumption, but also animal feed, animal health and welfare, and plant health, even when crossing international borders.
- **Importance of a multi-actor approach in the LSP to ensure demand-driven innovation**. Besides the necessary involvement of actors from the IoT supply side, the multi-actor approach requires the genuine and sufficient involvement of various actors beyond (end-users such as farmers/farmers' groups, agri-food and farming cooperatives, advisors, enterprises from the food chain, decision makers, public authorities, etc.) all along the project: from the participation in the planning of work and experiments, their execution up until the dissemination of results and a possible demonstration phase. The adequate choice of key actors with complementary types of knowledge (scientific and practical) should be reflected in the consortium and in the description of the project concept, and result in a broad implementation of project results. The multi-actor approach is more than a strong dissemination requirement or than what a broad stakeholders' board

can deliver: it should be illustrated in the project proposal with sufficient quantity and quality of knowledge exchange activities and a clear role for the different actors in the work. This should generate innovative solutions that are more likely to be applied thanks to cross-fertilisation of ideas between actors, co-creation and generation of co-ownership for eventual results. A multi-actor project proposal needs to demonstrate how the project proposal's objectives and planning are targeted to needs / problems and opportunities of end-users, and its complementarity with existing research and best practices.

The project should result in some practical knowledge which is easily understandable and accessible, and substantial in qualitative and quantitative terms. As a minimum, this material should feed into the European Innovation Partnership (EIP) 'Agricultural Productivity and Sustainability' for broad dissemination as 'practice abstracts' in the common EIP format for practitioners [15]. Facilitation/mediation between the different types of actors and involvement of relevant interactive innovation groups operating in the EIP context, such as EIP Operational Groups funded under Rural Development Programmes, are strongly recommended.

- **Geographical impact.** This is somehow determined by the robustness and availability to replicate and scale a given pilot in several EU regions. Special focus of this criteria lies on the technologies applied. On the one hand, the use of connected services and tools contribute to create a European ecosystem and so that the sharing of good practices and knowledge that can contribute to prevent and act quickly under special conditions. Furthermore, the acceptance and adaptability of the technologies to different sectors, holding sizes or production orientations under the smart farming and food safety is important for the replicability. On the other hand, the applicability in different regions despite the diverse climate conditions in Europe can contribute to the geographical impact. The complexity of the 'smart tools' should be adapted to the peculiarities of the farming and food safety in each selected geographic area.
- **Economic impact of the agricultural and farming activities.** With the global population increase, the demand of primary sector products has suffered an impulse that directly affects the economy. Due to this demand increase, management and traceability of production to prevent food loss or waste has become sometimes a difficult task. For that reason, the implementation of efficient processes for quality assurance and food loss avoidance is directly related to the economic revenues in each of the food chain states.
- **Economic efficiency** is significantly related to reducing supply chain barriers. Some levers related to product cost (e.g. reduced volatility of supply and prices, increased end-market prices and reduced costs) can help. However, IoT implementations can be applied to improve the whole process and reach sustainable profitability through its efficiency. In order to evaluate the short/medium term economic benefits brought by the application of IoT, one should consider all investments incurred: development, deployment (installation and equipment), future updates, replacements, scalability, maintenance, etc.
- **Environmental impact:** There is consensus on the benefits of introducing remote monitoring, control and application technologies to optimise input use efficiency, improve animal health and welfare, sustain product quality and safety, reduce the impact of machinery traffic on land, and promote effective delivery of environmental goods and services. Furthermore, the introduction of smart technologies in earlier stages of the agri-food chain can have important positive environmental effects across the whole chain. It is necessary to design a green infrastructure which help to make big-picture decisions that go far beyond greenhouse gas emissions, land conditions and air quality thresholds, and other operational and production efficiencies. In the livestock farming sector, and especially in the cases of husbandry or breeding, non-intrusive devices should be the preferred option not to disturb animal growth and reproduction and to ensure their security.
- **Use of mature technologies and services:** Nowadays, most IoT-related enabling technologies can be considered mature enough in terms of development, but there is still room for improvements in terms of their final application and practical deployment in the agricultural and farming sector. Some barriers are well-known, such as the rural wireless and broadband coverage, which still need to close the gap with respect to urban areas. The IoT can be brought closer to the primary sector market, possibly generating new business models, through a combination of approaches, such as the adaptation of already developed services in other domains, the integration between

complementary tools to generate a more complete and attractive product, or the validation in real or bigger scenarios such as those provided by a Large Scale Pilot (LSP). Moreover, available datasets such as those historically collected by cooperatives and unions during years (e.g. on yield mapping and recording, soil measurements, crop and animal data) just for production control, and data from weather stations can be used to feed novel applications and improve production processes, . Last but not least, security during deployments and in data transferred must be present in any LSP.

- **Societal impact.** Contribution to the different certification systems aiming to ensure quality products (organic production, designation of origin, etc.), maintenance of rural development through agriculture and livestock activity (focusing in family farms' sustainability etc.), contribution to the development of circular economy etc.

AIOTI WG06 has identified a number of **domains of application** use cases of potential consideration within the LSP on smart farming and food safety, which are listed in Annex 2 for illustrative purposes. They cover raw food production (conventional and organic), livestock farming (conventional and organic), food processing, distribution, wholesale, retail, and consumer side.

For the sake of illustration, we provide below some initial broad examples of potential use cases.

Everyday farming applications are based on data generated by sensors (moisture, soil composition, temperature, light, livestock tracking, etc.) and data gathered from external sources (for example, weather measurements or forecasts). The information from one farm could be shared or merged with that from other farms in order to generate aggregated value. This would be achieved by applying data analytics and presenting the results in different flavours depending on the final user, or integrating them in decision-making software applications. These use cases require smart devices replicable in wide scenarios of the European geography and adaptable to several farming scopes. Real time monitoring information and continuous status update benefit farmers with the opportunity of taking decisions to prevent and act re-addressing activities without the necessity to be physically present, thus optimizing the production process and improving revenues.

In a second example, all steps in the food supply chain (farmer, food processor, logistics and storage wholesaler, retailer, and even consumer) share a common infrastructure or application that allows the merging of relevant data generated at each of the steps, which provides added value teach of them. For example, this would allow intelligent decision making when planning harvesting dates or logistics operations, or allow traceability capabilities for food safety purposes, or simply for quality and/or origin certification.

A third example is the application of smart water management in agriculture. IoT-based systems are expected to actually improve the performance of irrigation systems in real conditions and over a significant amount of time, while offering desirable features such as low energy consumption, wireless connectivity over a diversity of distances, low maintenance costs, and high resistance against climatic influences. The effectiveness of these water management systems can be improved if the system is able to gather or integrate additional context information on natural and geological structures that have an impact on water availability and use, such as drought detection of soils, groundwater and catchment areas, leakages, or specific irrigation needs for specific crops. Next to water used for irrigation, IoT applications are also capable to improve the use of water in livestock farming. Application based on smart(er) sensing solutions can contribute to a better use of water resources in the following use cases: measuring use of water for individual livestock, use of water for cleaning operations, sewage and waste water recycling.

In any of the previous examples the use of standards provides the opportunity to adopt machinery and systems from different brands and companies —reducing the risk of vendor lock-in or monopolistic situations. The IoT standards go beyond allowing interoperability between devices and need to address data exchange, ways of presenting data, ease-of-access interfaces, apps, etc. enabling a new data-and-edge-driven IoT agriculture market to develop for both individual and aggregate services.

Further examples of use cases, and how they relate to the above relevance criteria, can be found in Annex 2.

2.3 Recommendations on the feasibility of a LSP covering Smart Farming and Food Safety

The relevance criteria given in Section 2.2 provide a very general overview of aspects that should be considered in the LSPs. The current section provides a complementary set of high-level, yet more detailed, recommendations which should help in shaping the LSPs.

The role of the smart farming IoT LSP is to foster the adoption of smart IoT edge devices, connectivity, data analytics, while building a strong IoT ecosystem around multi-disciplinary stakeholders that benefit from their business relationships by leveraging the implemented IoT systems to allow multi-party collaboration.

Marketable results

- LSPs should take into account the needs of both large and small farmers and demonstrate feasibility and the benefits of pilot solutions in both contexts. The predominance of small and medium holdings in European farming must be adequately considered here. The role of cooperatives and unions as demand aggregators could also be considered.
- Traceability, audits and monitoring procedures are usually perceived as a cost by farmers and stakeholders: in order to promote the acceptance of proposed solutions, it would be important to define sustainable business models ensuring that costs of IoT solutions are properly distributed in the value chain.
- Demonstrate an easier acceptance of the agri-technologies in the market based on the validation results obtained during the LSP execution.
- The technologies and solutions deployed in the LSP should come with a sound business model based on a clear demonstration of the costs and benefits for end-users. Their added value should be tested, validated and demonstrated in practice.
- The LSP on smart farming and food safety should strongly consider current real scenarios with users, industries and SMEs, local authorities and innovation managers fully involved in an open innovation framework driving the outcomes of the projects that will guaranty therefore, impact, sustainability, feasibility & replicability, involving well balanced stakeholders in social innovation and governance models aligned with EIP AGRI & EIP Water recommendations.

Technology

- End-users should be independent of specific proprietary solutions, so the LSP should include interoperability (communication layer, data handling and sharing, etc.) as a key priority to avoid vendor lock-in, allow changing service/hardware/software providers. Nevertheless sensor deployment shall be based on sensible solutions with regards to deployment and exploitation costs leveraging where relevant existing infrastructure.
- Some sub-pilots of the whole LSP could be based on already existing technology interventions on field that might be upgraded with the introduction of IoT technologies, while other pilot cases might start from scratch. Thus, horizontal interoperability issues among legacy and innovative systems could be addressed. Use of standardised protocols is encouraged to ensure interoperability.
- The considered hardware should be affordable and with low maintenance cost. The sensors should be user-friendly, easy to mount and maintain, and enable farmers to make the right management decisions and realise them reliably in the field, and include 'as-applied' data for sustainability reports.
- In the case of smart farming, the technologies and sensors deployed in the LSP should provide good performance in real farming conditions and robustness to cope with farm environment.
- Software and application management interfaces should be adequately adapted to ensure acceptability and ease of adoption by end-users.
- Deployed technologies should be based on standards or ongoing standardization initiatives, following the guidelines provided by AIOTI WG03.
- Data ownership and authorship is a key issue. Clear rules/governance of data ownership and

security should be considered to ensure that the data generated are available for its use by the different stakeholders involved in the pilot, and can be shared across different pilots/domains. Open Data shall be considered for the data collected during the LSP (regarding valuable information for or the consortium and statistical studies for project validation).

- The data available from the IoT should be presented to the final user in a unified way and abstracting the underlying components and layers with a straightforward, user-friendly and application-oriented visualization.
- In the case of data that may contain personal data from individuals, the solutions should carefully deal with and solve the issues related to the affected individuals' privacy and enforce a respectful collection of data (agreed consent).
- Easiness of interpretation of outputs and data. Straightforward information which can be easily linked to the farmers' decision making process.

Legacy issues

- The livestock farming and food processing domains are already regulated at EU level, but specific regional differences exist in how the policy is implemented: for this reason it would be important to assess feasibility and pilot identical use cases in different regions to maximize significance of achieved results. The Compliance of EU Animal Welfare legislation will be also considered (In 2013, the European Commission has adopted a proposal for a single, comprehensive animal health law).
- Because of regional differences, several region-wide or nation-wide ICT systems already exist in order to support food safety authorities in tracing and tracking livestock and food products. Studying how IoT systems could interoperate with such sensible (and usually closed) systems would be important. In fact, access is normally restricted and represents an important barrier to be overcome in a pilot: this should be addressed by engaging in the pilots both food-related authorities and providers of the relevant ICT solutions.
- Due to the relatively low granularity of information available today, food safety regulations are thought with high safety margins to ensure that no risk occurs for consumers. The application of a technology allowing very strict and continuous monitoring would probably result in the detection of a very large number of warning situations. An important result of pilots could be an analysis on how checks and regulations could be relaxed (thus saving money) thanks to the application of such technology, while keeping the same level of safety

Societal Scope

- Societal acceptance of the new technologies, tools or processes tested within the LSP should also be included as a dissemination objective in the cases where it is considered important for its success.
- Education and training aspects should be included in the LSP to help end-users understand the use and usefulness of the new technologies. The LSP would benefit from integrating initiatives already running for the "education and farming": they would represent a well-proven way to disseminate IoT culture among youngsters and the stakeholders of the food chain. In addition, concrete measures to enhance digital skills in along the agricultural value chain could be proposed, including academic partners into this process.

The time frame of the pilots included in the LSP should be chosen so as to provide meaningful evidence of the benefits of the particular application cases. For example, pilots focused on plant farming should be operative for at least one growing cycle. Similarly, pilots addressing livestock farming operations should cover a complete operative process.

All in all, the LSP should help to create a framework and ecosystem to enhance the leadership position of European industry and foster global co-operation, taking into account the structure of agriculture in the EU as a basis to establish innovative models that may put established structures into question.

3 Investigation of the technological dimension for the large scale pilot

3.1 Mapping of relevant IoT-related technologies and standards applicable to Smart Farming and Food Safety

The Internet of Things concept covers and joins a variety of applications, domains and technologies, each one with their inherent characteristics and specific challenges, Smart Farming and Food Safety being one of them. Thus, in order to accommodate to their requirements and needs in a scalable and modular way, an architecture reference model needs to be established. At the moment, several architecture reference models have been proposed by various initiatives and projects. At the European level, the IoT-A project [16]has managed to create a reference architecture with this purpose in mind. The IoT World Forum aims also to create an architecture reference model to deal with these issues [17]. Standardization organizations such as the IEEE Standards Association are also working with this objective in mind [18]. Each one of these efforts tries to propose a framework for defining the main layers, entities, concepts and relationships in the IoT domain.

From a technological point of view, five groups can be established to sort technologies, architectures and standards:

- **Enabling hardware**: Smart devices from several vendors are being used with sensors, actuators, communication gateways and other appliances (including those integrated within agriculture machinery) for several purposes in Smart Farming and Food Safety. On one hand, in the Smart Farming domain, these devices are typically used to gather information from the fields, animals, and farms, and processed afterwards for creating models, forecasting behaviours or applying other analytical techniques. Examples of parameters being monitored by sensors can be soil moisture, leaf wetness or calf temperature. Actuators are used for example for smart irrigation or automatic feeding. On the other hand, in the Food Safety domain, smart devices are being used for quality monitoring through the value chain (spoilage, break of the cold chain, etc.) or for interacting with smart labelling. Where suitable, energy harvesting techniques could be adopted to define more flexible solutions and reduce maintenance costs. Another important element to be considered is the Gateway which will allow transmit data between the smart devices and the network domain.
- **Enabling software**, including middleware**:** Devices are more and more intelligent and able to take autonomous decisions thanks to their embedded software. In the past few years several operating system initiatives for embedded units, smartphones or other devices have appeared, helping to manage and create new embedded applications, thus improving device and infrastructure intelligence in the end.
- **Enabling communication technologies:** The variety of IoT applications causes that the used communication technologies are diverse depending on the inherent characteristics of each solution. For example, tractors and other agricultural machinery, which are currently equipped with several monitoring capabilities, rely on standards such as CAN Bus J1939 [19] or ISOBUS [20]. Other applications rely on wireless technologies using battery powered devices in environments where using wired technologies would be too costly. In this regard, it is interesting to pinpoint the widely implemented ISO11785 and ISO14223 standards for radiofrequency identification of animals. Current approaches in the wireless field are oriented towards a variety of networks such as WPAN, WLAN, LPWAN, cellular networks and many more, enabling other applications beyond identification.

  Otherwise, such data about tractors will contribute to the monitoring and improvement of process, while the cooperation among tractors (if multiple of them are foreseen) has the potential also to improve the accuracy of precision farming itself.

  The use of existing long-range communication protocols that are presumed to be already available (e.g. 3G/GPRS, LoRa Alliance or SigFox) may pose an advantage for some application cases, since it removes the need to deploy a new data collection infrastructure, thus accelerating system deployment.
- **Platforms:** Once data is retrieved from smart devices in the edge of the networks, it is managed, stored and further processed for visualization or other type of operations with the help of several platforms or cloud services. For example, FIWARE [21] is a platform created through European

public-private collaboration aiming to grant interoperability independently from the underlying protocols or standards used while contributing other tools with analytical, visualization, storage and many other purposes. SOFIA2 [22] is also a similar platform with akin objectives. There are also many platforms from private vendors such as Cisco, Thingworx, Microsoft, etc.

- **Services:** During the following years the number of IoT devices and the data provided by them is expected to increase greatly. However, having such a high amount of data serves no purpose if services to tackle users' issues and needs are not devised. Besides, adequate tools are needed to give them needed support. Thus, two service categories can be established: end services directly provided to users and those created by service providers to support the former. For example, users may want to have cattle localization, traceability or meteorological services. Moreover, cloud computing, storage or data analytics are services that may be used to provide the former functionalities. These services may involve several actors which can interact through common internet interfaces for machine-to-machine such as REST web services.

The following table contains a non-exhaustive summary of relevant technologies, platforms and standards, according to the classification introduced above.

Table 3.1: Summary of technologies, architectures, platforms and standards

Technology levels	**Available technologies, architectures, standards**
Enabling hardware	Sensor types: • Environment, chemical, mechanical, acoustic, ultrasonic, electric, optical, computer vision systems, biological, MEMS, RFID Sensor standards: • SensorML, ISO/IEC 29182 Actuator types: • Hydraulic, pneumatic, electric, mechanical, thermal Hardware interfaces: • RS-232, RS-485, I2C, SPI, IEEE 1451 Processors: • ARM, x86, PPC, MIPS, multi-cores Antennas Energy harvesting solutions and power management
Enabling software	IoT/embedded OS: • Embedded Linux, Windows 10, Brillo, QNX, Contiki OS, RIOT, FreeRTOS, Tiny OS, OpenWRT Smartphone OS: • Android, iOS, Windows Phone, Blackberry OS, Tizen
Enabling communication technologies	Wired: • Ethernet (IEEE 802.3), CAN bus J1939, ISOBUS (ISO11783), IPv6 Wireless: • RFID, NFC, ISO11785 and ISO14223, IEEE802.15.4, ZigBee, Wi-Fi (IEEE802.11), 6LoWPAN, LoRa, Bluetooth variants (IEEE802.15.1), Z-Wave, DASH7, Weightless, UWB, other RF links… • Cellular: ○ GSM, GPRS, UMTS, HSDPA, LTE, WiMAX, LoRa Alliance, SIGFOX… Satellite communications Manufacturing oriented: • PROFIBUS, PROFINET, IO-Link, Modbus, OPC-UA, FDI, ISA100.11a, HART, WirelessHART… High-level protocols and languages: • AgroXML, HTTP, Websockets, CoAP, Web REST services, MQTT, UPnP,

	WFS,WMS
Platforms	Platforms: • FIWARE, SOFIA2, Carriots, Farmsight, Libelium, Thingworx… Farm Management Information Systems (FMIS) Standards used by platforms: • CKAN (Open Data), NGSI, ODBC IoT architectures: • IoT-A, IEEE, ITU-T, IoT World Forum, IIC's IIoT Reference Architecture, and ongoing work at ISO/IEC/JTC1 and ITU-T.
Services	Localization: • GPS, GALILEO, GLONASS, RTK… HMI: ○ Dashboards, information panels, augmented reality Weather information systems Cloud technologies • SaaS, IaaS, PaaS, elastic computing, storage… Service Oriented Architectures (SOA) Data analytics services • Anomaly detection, trends, time series, Hadoop, Spark… Drone surveillance

3.1.1 Example of high-level system architecture

Figure 3.1 shows a high-level representation of a M2M/MTC system architecture relevant to a generic smart farming production scenario, constituted by three main domains: Device, Network and Application:

- The Device domain is in charge to sense and act with the physical world. It is composed by smart sensors/actuators which will get data from the physical world and will transmit them to the Cloud for processing and analysis.
- The Network will recover all the data in the Domain device or send commands to the actuators. It will process the information received and deliver it to the application domain.
- The Application domain, that may include the IoT capability layer of AIOTI WG03 high-level functional model, is in charge of analysing and using the information received for performing the actions according to the defined application.

The Device domain is key in an IoT architecture or M2M system architecture and comprises three main components:

- Sensor node/smart device/Cyber Physical System (CPS)
- Aggregations Points
- Gateways

The sensor nodes or CPS are generally constituted by three main elements: a sensor/actuator, a processor and a communication transceiver. The sensed data is adapted and processed before being transmitted to the cloud directly or via a gateway.

A gateway is a component in charge of translating a protocol coming from different networks. It allows the transmission of data between the smart nodes and the cloud where the data will be processed/analysed remotely.

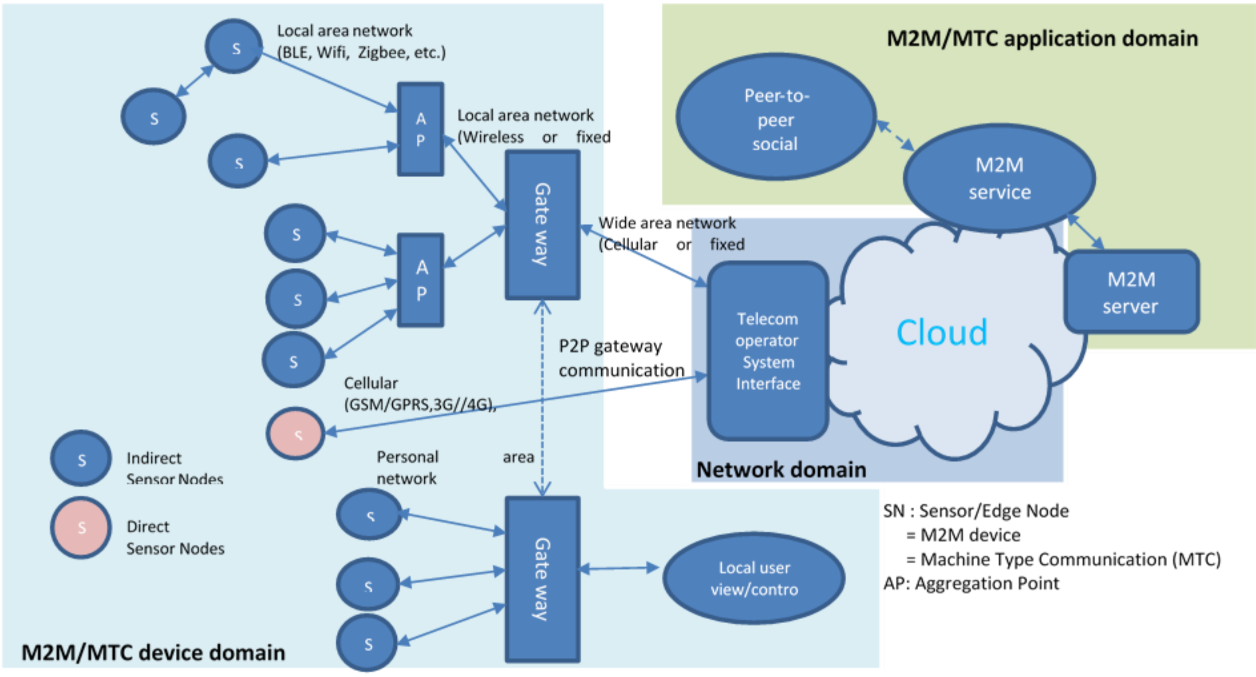


Figure 3.1: High level representation of a M2M/MTC system architecture

3.2 Requirements for the selection of technologies, standards, and interoperability for the LSP

The IoT architecture mode should be flexible enough to properly cover requirements from territories with dissimilar characteristics such as areas where smallholdings are the main agriculture model (e.g. Northern Spain, greenhouses and intensive horticulture,…) or areas where larger fields are harvested (e.g. Germany, extensive horticulture and field crops,…). Typically, in the former case the concentration of users and feeds of information will be higher for a given place. Hence, for example, shorter range radio technologies may be used as well as proper communications planning and scheduling procedures. Privacy preservation measures should be followed also. However, in the latter case the architecture model will need to deal with higher distance transmissions so higher range radio technologies may be needed to cover a field. On the other hand, LPWAN solutions can cover both requirements and thereby provide a unified approach for the two segments or to use gateways to reach the gap and adapt the transmission between short and large communication range.

The IoT architecture model used by the pilot should also ensure compatibility with current deployments made by farmers in their fields or inside their barns. Farmers should not have to completely change their infrastructures with new equipment. Nonetheless, wherever new deployments have to be made, open hardware and software solutions common to everybody should be used. For both cases, interoperability can be achieved at the data level, creating common APIs that are independent of the underlying protocols.

Systems and smart devices being used for Smart Farming activities should have proper mechanisms and communication capabilities to ease their deployment and allow to dynamically add more nodes. Thus, new use cases can be exploited with little effort. Standard communication interfaces and APIs, self-configuring methodologies, semantic interaction and other methodologies will help to achieve this objective.

In the past, precision farming applications focused on using data recovered from fields for improving economic revenues and farm attributes with little or none social implications. The wide amount of data generated by IoT devices, deployed in crop fields or in animals, shall be used when possible by the community. Therefore, proactive measures may be taken if pests, plagues or animal diseases are detected, preventing their spread. Open data models and platforms should be used for this purpose while maintaining privacy measures and protecting farmers’ interests.

However, it must be noted that raw data as directly collected by IoT devices may have little value for the sector. Due to the complexity of food-related use cases, raw data and processed information must be made available to different stakeholders with different levels of granularity. Scalable, dynamic, context-aware data distribution techniques would be critical with respect to this issue. In addition, business models for deploying IoT sensors and delivering meaningful information may involve proprietary data and analytic algorithms and hence require subscription fees or similar.

Common semantic models should be used by all actors so that interoperability between actors in the value chain can be achieved. An existing interoperable framework may be adopted or a new one created if it does not exist in order to achieve semantic interoperability. A particular solution can use own proprietary semantic model, but has to provide relevant data through a commonly accepted semantic model for use in other systems.

Regarding the especially delicate topic of Food Safety and Traceability, the food industry requires traceability systems to ensure a higher level of granularity through the value chain and inside each of the stages where products are processed. Many traceability and monitoring-related use cases are about making sure that specific food conditions are kept constant. Event-driven processing of data from heterogeneous sensors, jointly with context-aware techniques and dynamic rules filtering may be a key technology to raise alerts and warning when specific conditions occur.

Identification standards and technologies (e.g. EPC and related standards, bar codes, etc.) and inter-linking among different addressing techniques will be crucial to make sure that different parts in a food traceability scenario can be properly referred to and logically inter-related. Since NFC and RFID are not applicable at all time and for all markets, a mix of logically inter-linked identification technologies will be needed.

Real time detection of target compounds is fundamental to guarantee a high level of the safety (chemical, microbiological) all along the food chain, and should be based on on-line/in-line technologies, miniaturized sensors and automated platforms. Technologies should demonstrate fit for purpose and suitable capacity of detection of the target compounds under real working conditions. Fast response and data transfer rate would be also advisable. Applicability of the technological platforms is often strictly related with their flexibility and capacity to be adapted to different practical cases.

A balance between data that may have to remain private and the share of open information should be achieved. Customers will be grateful to know the product is in good shape but they may not need to know sensitive information from companies that may need to be incorporated for self-traceability purposes. Thus, an access control policy must be established to ensure data security.

Integrity of the data must be ensured by all means. The origin of the product, the stages it passed through and other sensitive information must be known. Guarantee the trustworthiness of the source is one of crucial requirements. In this aspect, privacy and security of data shared must be also ensured. AIOTI WG04 “Policy issues” covers considerations, standards and initiatives of interest to take into account in this regard

Table 3.2: Compilation of relevant requirements that may be used in the selection of technologies and standards for the LSPs

	Selection criteria		
Technology levels	**Requirements**	**Technology KPIs**	**Do previous tests / implementations exist already?**
Enabling hardware	• For new deployments, open hardware should be used if possible to avoid vendor lock-in. • For older deployments, proper methods to interact with legacy hardware may be devised • In an agro environment low power technologies will be useful. Self-powered hardware will help to harness self-sufficient operations • Hardware architecture standards should be used so components can be easily incorporated into reference designs • Robustness, reliable and secure components • Affordable cost for deployments • Low maintenance, high autonomy, environmental endurance	• Open licenses being used • Device energy consumption • Hardware lifetime • Sensors. Time between calibrations	DIY projects Energy harvesting: • EnOcean • Voltree Power • Micropelt • However, for certain use cases such as mesh networks energy harvesting is not yet technically feasible Standard sensor models: • OGC (SensorML) • IEEE1451
Enabling software	• Devices and infrastructure should be intelligent enough to serve farms without stable communications with the Internet • Software should be aware of the device they are running on in order to adapt to its resources. Cloud service deployment may be a good option when there are no connectivity problems. • Well-adopted by industry, open • Compatible with multi-actor approach • User friendly interfaces	• Deployment effort • Compatibility with existing infrastructure • Learning curve	Smartphone OS Embedded OS
Enabling communication technologies	• When mobility is needed or for large deployments wireless technologies are encouraged • Communications technologies should be resilient to external factors and possible issues in the infrastructure • Technologies and models that allow to easily connect new devices with legacy systems should be used	• Expected distance between deployed devices • Reliability • Latency • Range • Communications coverage	Mesh deployments in several test pilots. Smart Agri-Food Meshlium (Libelium) EU-PLF FINoT (Future Intelligence)
Platforms	• The chosen architecture model should be flexible enough to cover requirements from territories with different needs (geology, orography, agriculture models, etc.) • Standard interfaces and APIs are needed to connect applications or services from Farm Management Information Systems (FMIS) • Platforms should allow to compose services tailored and personalized for each user	• Degree of interoperability • Scalability	FIWARE (FRACTALS, FINISH), Thingworx, Libelium, Smart Agri-Food

	• Platforms should enable a better interaction channel among service providers and stakeholders • Platforms should support scalable models so they can dynamically adapt to the needs of the farmers • Platforms should use standardised models for representing data (syntactical interoperability) • Platforms used should be, if possible, open platforms		
Services	• Use open data models and platforms in order to create a scalable virtual and global environment of cooperation • Users should have control over how their data is being used and for what purposes. Privacy must be preserved • Even if decision support systems are used, in the end the farmer should have the last word to apply some expert system advice • To fit the above mentioned use cases • Coexistence of open and proprietary services	• Quality of Experience (QoE) • Amount of data analysed • Privacy protection degree	UK government agriculture open data, Smart Agri-Food QUHOMA

3.3 Recommendation on the feasibility and replicability of the LSP

The high-level recommendations provided in this section complement the requirements identified in Section 3.2 above.

General recommendations

- Data ownership is a key issue. Clear rules/governance of data ownership should be considered to ensure that data is available for its use by the different stakeholders taking part in the LSP.
- Reliability of the data is important, including reliability of the devices and also the processes involved in their processing.
- The relevant data may not be those directly recorded through IoT but those derived from fusing them with other sources through domain-specific tools. This may involve other proprietary data and algorithms. One example are weather forecasts, which might be necessary for valuing certain IoT data but their access requires subscription. Commercial feasibility may require a flexible coexistence of open and access-restricted resources.

Feasibility

- Smart Farming
  - The chosen technology for communications with nodes deployed in fields or animals will need to be based on wireless standards. Wired deployments are too costly and not useful for mobility use cases.
  - When using wireless communications, range and network coverage should be taken into account.
  - Low power technologies should be used. Battery powered devices should have power for years when deployed in a field in order to diminish costs. Strategies for recharging those batteries should be contemplated (solar power, energy harvesting techniques) to increase device life.
- Food safety and traceability
  - Traditionally, tracking by using RFID or NFC tags has been problematic due to the cost associated with this technology compared with the cost of the product. New technologies like functional ink sensitive to environment conditions combined with secure scanning can provide substantial benefits to both producers and consumers. Alternative solutions to achieve costs compatible with the application shall be considered for LSP.
  - The applications focused on monitoring chemical and microbiological hazards in the food chain should be: i) based on miniaturized (nano)sensors, ii) suitable for real time detection at the levels of interest and iii) easy to implement on-line/in-line at industrial level.
  - Different local regulations and labels in different countries and local regions difficult feasibility as well

Replicability

- General
  - Standard interfaces between the different levels of the IoT ecosystem should be used. This will allow easy replication of situations and architectures easily in different conditions.
  - APIs at the highest level should be clearly defined. High level applications need a stable way to access lower level information.
  - For open data sharing, standard management systems like CKAN should be used.
- Smart Farming
  - Historical data from past problems with plagues or pests should be shared. The conditions that caused a problem in a given place may prove to be useful to avoid the same situation in another site.
  - Pilots should be deployed in regions with different agricultural conditions (soil moisture, temperature, soil composition, types of cultivated crops, etc.). This will allow to test that the technologies, architectures or devices are valid for a variety of conditions.
  - To provide factual and undisputed conclusion the LSP shall include A-B testing

- Food safety and traceability
    - Methodologies used for food traceability should be valid for every type of product, independently from their inherent characteristics.
    - Sensing and IoT technologies applied in the field of Food Safety need to be validated in comparison with recognized, official methodologies and protocols.

  For both, farming and food safety and traceability, standardisation and calibration of analytical techniques in the different labs responsible to develop them is a key point.

4 Recommendations for the testing of business models and of user acceptability

Before making recommendations, it is important to highlight the agri-food ecosystem from an economic and strategic point of view.

4.1 The agri-food value chain

The agri-food value chain can be characterized by its:

- Diversity: there are many different food types, with its own distinctive and often fragmented supply chain,
- Complexity: there are many specific actors from input companies, farmers, traders, food companies and retailers to consumers,
- Volatility: which is mainly linked to unpredictable weather and yields, climate change, political actions and social changes,
- Scrutiny: now consumers want to know about the content and safety of their food, where and how it is produced and what the environmental and social impacts are.

Despite that, there are many temporal or permanent interdependencies among actors, which are not only between the functions linked along the chain but can include actors anywhere in the chain.
Collaboration becomes decisive regarding food safety and traceability, with a balanced participation of stakeholders representing farmer associations, authorities, SMEs, infrastructures support, food processors and sometimes consumers.

The main stakes of the different actors constituting the agri-food value chain are described in the following sections.

4.1.1 Production

Farming position in the value chain is between powerful input suppliers (e.g., seed, fertilizer, machinery) and retailers. It is also the most risky activity in the value chain.

Volatility of input costs and selling prices, unpredictable weather and yields, and long production cycles are particularly difficult to manage and not adapted to respond to market changes. Furthermore financial practices such as future markets or strict food chains use to fix a very low cost for food products at the origin and make production unsustainable.

Farms often struggle with economic scale. Productivity enhancement means generally investment in new inputs (equipment, etc.). Farming has then very low margins and investments in innovation are difficult, especially for small farms.

Finally, capital is becoming an issue. The private investment community has begun to invest in farm property, often perceived as “land grabbing”. Landowning and farming are separate businesses with different risk and return models. Landowning aims to make only profits and increase the land financial value.

4.1.2 Processing

Food manufacturers are important members of the food value chain. They will need to support the expected global population growth. It will require significant changes to product line, distribution channels and supply chain.

Collaboration throughout the value chain is also important to this group, as the manufacturing of food, the central activity of the value chain, requires both up and down stream collaboration.

This group is composed of relatively diverse companies processing products at different stages: meat slaughtering and processing, fruit and vegetable preserving, grain and oilseed milling, seafood product preparation, sugar and confectionery, bakery, dairy, and other food product manufacturing.

Finally, global mergers and acquisitions have been critical to enabling large multinationals to achieve economies of scale and find new ways of growth.

4.1.3 Distribution

The stakes of distribution concern mainly the optimisation of logistics, transportation and storage, but also the respect of some technical, social and environmental constraints (temperature, drivers working conditions, pollution, etc.)

4.1.4 Wholesale & retail

Retailing is widely recognized as a highly competitive industry. Consumers have a large choice of retailers and retail channels. Retailers continuously try to differentiate themselves and provide a good value proposition to consumers based on the right balance of price, quality and service.

In particular, quality plays a key role in the consumer’s path to purchase and the level of quality assurance that consumers demand continues to rise, especially for fresh products.

Besides, the notion of “sustainable”, “organic” or “green” products seems to have more and more appeal to specific consumers group.

Finally, the growing importance of the e-commerce channel requires innovative solutions to make sure that the logistical process is cost effective and the advantages of an online sales channel are leveraged as much as possible.

4.1.5 Consumer

Food security, prices, safety and quality summarize the concerns consumers have about food. An increasing number of consumers are demanding greater transparency in the food supply, including the origin and contents of the goods (especially allergens such as gluten), and the sustainability of the growing and transformation process. The trend is to answer to the consumer individual expectations.

Moreover the increase in demand, coupled with rising energy prices that feed into the cost of producing and transporting food, could result in higher retail prices.

These consumers' demand and consumption patterns affect the organization of the all food chain.

4.2 Recommendations for the testing of business models

4.2.1.1 From the agri-food chain side

Smart technologies can impact existing business models and create new ones, such as:

- Value creation of existing products which become connected, allowing for example transparency on products for consumers,
- Optimisation of business such as costs savings or waste reduction of perishable products to optimise revenues,
- Interconnected effects through ecosystems with big data and data sharing.

Value is based on data and associated services. IoT is going to accelerate the development of services and the transition of product to service.

In the agri-food chain, global benefit expected by smart technologies is the contribution to make it more efficient, equitable, sustainable, safe, and better performing. Smart technologies can help reduce supplier barriers, especially related to product cost (for examples reduced volatility of supply and prices, increased end-market prices and reduced costs), and modify the value chain. Indeed, with the possibility to collect and run new data, actors of the agri-food chain could grow outside their traditional positioning. Some actors could reinforce the consumer relationship while others could be disintermediated. IoT could lend more weight to small actors.

Each group of stakeholders in the agri-food chain has its own business issues. Introduction of smart technologies can impact differently those business models.

On the production side, the promise linked to smart technologies is high. Some of the expected benefits of smart farming are:

- Increase productivity: increase yields by optimizing growth and harvesting processes for example,
- Reduce cost: cost of resources (water, energy), lower fertilizer and pesticide usage for examples,
- Enhance environmental issues: water and energy consumption, animal feed, health and welfare, plant health, soil pollution, etc.
- Help predict the property value of farms and have insight into the commodities market,
- Move closer to consumer demands,
- Improve communication with consumers and food processing companies,
- Strengthen position in the value chain
- Reinforce governance support of farmers' local communities and improve decision processes.

The needs and benefits between large farmers and small farmers are different.

For food manufacturers, food safety has become a critical concern. Smart technologies can help them to enhance product labelling and traceability in order to improve supply chain transparency. IoT could also reinforce their positioning compared to retailers with more access to consumers data.

On the distribution side, smart technologies can mainly contribute to optimize and improve freight, transport and storage. IoT brings two main elements: information instantaneity and increase of the number of available data. It could allow checking some constraints (temperature, humidity, package opening, etc.) and having information on trucks filling ratio or driver tiredness.

For retailers, smart technologies can help to meet the changing needs of consumers who expect to have full pricing and product transparency before making their decisions. Active packaging and smart tagging can offer value-added functionality. For example, smart tags using temperature and/or quality sensors can monitor freshness of a product through the entire value chain. Indicators of product status can be available to both sellers and consumers.

However IoT could challenge the positioning of retailers in the value chain with the risk to be disintermediated by food manufacturers or producers which will have also access to consumers' data.

Finally, for consumers, smart technologies answer to the demand of more quality and transparency such as food components, breeding conditions, cultural practices, etc. IoT could also facilitate new ways of consumption such as periodic unfixed fresh products, or cooperatives of organic food consumption.

Regarding costs, farmers have very low margins. Investments in innovation are difficult and farmers usually count on public support. Cost for smart farming is still high, especially for small-field farming. Some technologies such as RFID or NFC are still problematic due to the cost associated with this technology compared with the cost of the product.
Exceptions are largest farms with stronger financial capabilities, such as in the US (see examples in section 4.2.2).

4.2.1.2 From the IoT providers side

Several business models could be considered on how ICT providers can sell IoT in agricultural and farming sector:

- Sale of hardware (sensors, etc.) by manufacturers directly or through service providers, with free basic applications,
- Premium subscription for value added applications,
- Advertising based model: free value added applications with advertising,
- Data value based model: free value added applications in order to retrieve many data in platforms, and reuse or re-sell data in specific ecosystems.

Some options are to be considered in successful IoT business models:

- Open innovation and collaboration which imply the development of strong ecosystems able to share data, know-how and experiences across the overall ICT value chain,
- Supplies of end-to-end solutions (conception, integration, maintenance, etc.),
- Strong knowledge of the agri-food sector,
- Promotion of solutions through associations related to each specific agricultural and industrial food sectors.

Costs of IoT solutions include hardware, development but also deployment (installation and equipment), future updates, replacements, scalability and maintenance. The quantity of sensor nodes and deployed systems is a key cost element. Moreover, costs will be higher with a fragmented market compared to generic solutions using standard interfaces, ensuring interoperability between different providers.

Finally, open source solutions can be promoted as they are usually cheaper than proprietary systems. Also they can be much more flexible and customized for the application purposes. But the main problem in open models is related to support, maintenance and after-sale. Indeed API can change and old versions cannot be available anymore. And it can be more difficult in rural area to find open source experts.

4.2.2 Examples of business models currently in use

In the US, with its large farms structure, the market is the most advanced. Some input suppliers are investing in the ICT domain and propose precision farming offers.

For example[2], Monsanto acquired Precision Planting Inc. in May 2012 to reinforce its prescription offering. Other big companies operate also in the precision farming market including Deere & Company, Trimble Navigation Ltd., Raven Industries, and AgJunction Inc.

DuPont, Monsanto’s key competitor, launched its **Encirca farm services**, with the following offer:

[2] http://www.forbes.com/sites/greatspeculations/2014/03/11/duponts-encirca-farm-services-to-bolster-agricultural-revenues/

- Basic free service: it allows growers as well as Pioneer (DuPont's seed company) agents to record and share crop observations. Growers can also directly reach out to DuPont experts for any advice on crop management through this platform.
- Premium package (about $150 per month): it includes market news and analysis, grain-trading capabilities, and field-specific weather forecasts.
- Future fee-based service called Encirca Yield ($10-20 per acre expected): it will help growers assess specific decisions on planting seeds, application of pesticides and water usage.

DuPont expects to generate more than $500 million in incremental annual revenues from these services in the long run, which is around 4% of its 2013 agricultural products sales revenue.

It should be noted that the American Farm Bureau Federation published a potential risks outline relating to the data mining in the agricultural industry and on farm tools[3]. Farmers especially fears that price discrimination may appear if big input suppliers use data to charge them a different amount for the same product or service.

In the EU organic and sustainable farming market, **QUHOMA** (QUalitative HOrticulture Marketplace)[4] is an example of FIWARE-Future Intelligence's farm services. The QUHOMA platform is a data-centred community and marketplace for promoting qualitative horticulture. Hardware (FINoT equipment) is provided for free to farmers and access to relevant data is provided upon subscription to agronomists/mentors and Quality Certification bodies:

- Basic (operational) service packet: farmers who have subscribed to QUHOMA can remotely manage their farms through a WebApp. Then, they can purchase operational (WeedHandling, PlantProtection, etc.) advice packets from mentors on a pay-per-use model,
- Tactical service packet: additional to the basic service, farmers can now enjoy training and holistic farming management advices with a discount,
- Strategic service packet: farmers can now buy business intelligence advices and discounted certification products.

In Italy, **AgriAware** is a traceability project that follows the transformation of olives and other fruits from the tree to the packed product. This information is offered to consumers who are paying for high quality products and want to have evidence about the origin of the product. It includes software for agricultural assistance, supporting farmers on biological/organic crop production, based on environmental conditions monitoring. It also includes a collaborative platform for business planning and food quality improvement.

A possible business model from the ICT side could be the following one:

- Basic model: direct selling of the system to producers/farmers including hardware (smart tags, sensors, climate station and other needed equipment) and software interface (Web based and app) for laptop and mobile devices,
- Core package service: mmaintenance/assistance to producers/farmers including assistance on hardware problems, firmware and software update, and customization of the software (including adaptation to changes in the production process),
- Premium services:
    - Subscription services to the FarmerAssistant app: this service helps farmers in crop management providing an adviser and DSS (Decision Support System) tool. A special version is available for organic producers to reduce pesticides and adopt biological treatments.
    - Advertising revenues on the TrustLabel app: reading a QRcode (or similar) on the food label allows the grower to give customers extended information about the product, not available directly on the label, such as traceability, pictures of the production field, nutrition facts, etc. This grants more transparency to the customer.

[3] http://www.offthegridnews.com/privacy/monsanto-buying-of-massive-farm-data-has-farmers-nervous/
[4] http://www.quhoma.com/

- Selling of aggregated and anonymized data generated from the FarmerAssistant App: information collected from the fields and crop ripening can provide punctual and specific information about the weather forecasts, the ripening situation along the reference business country.
- Analytics and other services generated from the analysis of the aggregated historical data on environmental conditions (temperature, humidity, rainfall) combined with data on the treatments, harvesting time and quality and quantity of produced oil. Then the system can support the farmer in evaluating the effects of certain treatments, trees productivity, etc.

The expected benefits from the farmer side could be:

- With the Trust Label app, the farmer can gain visibility and trust with the customer. This can lead to sales improvement and brand recognition. Moreover the app helps the farmer with special advertisement campaigns, linked for instance to a production lot instead of a specific time, changing the current "special offers" model. In addition he can promote additional services, like accommodation, touristic or educational offers in his farm. Finally the app helps the farmer to be compliant with the voluntary extended label requirements in EU.
- With the FarmerAssistant app the farmer has a quick tool to learn about best practices and can:
  - Improve crops quality and quantity,
  - Enter into new market segments, for instance when moving from traditional to organic or dynamic agriculture,
  - Reduce mistakes for new entrants into farming or new cultures,
  - Spend less money thanks to a better management of pesticides and water.
- In adopting the software, the farmer has a DSS in house. In fact he has the ability to monitor remotely the plantation and collect data for statistical purposes. He can then understand the trend of its production during and across the seasons, and decide about future farm and production management (investments, costs, diversification of crops, adoption and results of special treatments, like different pruning methods, etc.).
- In buying aggregated data from the system, the farmer has an additional DSS to decide or adjust products price, to find where to sell, regarding the seasonal production trend, and to decide when participating in product competitions.

In Spain, the **MEGA** project[5] aims at addressing specific problems of control, interoperability and management of irrigation water distribution networks for users associations that are mainly composed of farmers. MEGA is based on EN 61512 (S-88) and EN 62264 (S-95) standards, and provides a reference architecture for water management processes. The aim is to save cost of energy and water and to make all ICT infrastructures and further innovations provider-independent, empowering farmers and their production. The MEGA project is supported by the Spanish Ministry of Agriculture Food and Marine.

4.2.3 Recommendations

The following elements should be taken into account for the testing of business models:

- **Benefits issues**:
  - Test the solutions on different agri-business sizes and productions in order to understand which sectors and business sizes can benefit more of these solutions, and suggest business strategies (for instance commercial alliances or farmers aggregation),
  - Involve stakeholders at the beginning of the pilot to identify real needs and expected benefits,
  - Demonstrate feasibility and benefits of the pilot.

[5] http://www.gestiondelagua.es/en/

- **Cost issues**:
  - Ensure compatibility with current deployments made by famers and adaptation of already developed services in other domains, so farmers should not have to completely change their infrastructure with new equipment,
  - Consider alternative solutions to face costs compatibility,
  - Promote generic solutions ensuring interoperability between components and systems performing the same functions, and between the different elements of the ICT chain,
  - Offer robust and affordable solutions with low maintenance cost.

- **Cross-cutting and trusted approach**:
  - Focus on horizontal approach and not only vertical ones, which would reinforce silos,
  - Ensure collaboration between actors of the chain, especially competitors and new partners, legal compliance and liability across all business actors,
  - Ensure collaboration and association within farming communities and innovation social spaces in any food sector or at any specific regional level,
  - Develop win-win solutions that bring together the primary sector and the food industry, in order not to accentuate existing economical unbalance and asymmetries,
  - Distribute costs, potential added value and profit margins associated to smart technologies at each level,
  - Create strong ecosystems to share hardware and software solutions, know-how and experience, and so ensure the richness of these solutions to cope with the needs of smart farming and food safety applications,
  - Build strong relationship between technological and agri-food actors, especially at the local level (local ICT provider, SMEs committed with the innovation social, authorities, etc.),
  - Take into account data ownership issues and ensure data privacy,
  - Ensure trust with the concept of "trusted third parties" such as telecom operators for collection, storage and data availability, existing specific operators for economic and administrative data, certifiers, etc.

- **From pilot to market**:
  - Consider the cost of maturing the implementations from the current Technology Readiness Level from its state in the pilot until the commercial state,
  - Quantify costs and benefits in an environment close to the final exploitation scenario, especially regarding subventions,
  - Propose at the beginning solutions at low price with reduced margin until the critical mass of adopters is reached,
  - Ensure that the LSP approach is clearly demand-driven, ensuring acceptance and uptake, involving end-users during the whole duration of the project in order to accelerate market acceptance and wide deployment of innovative ICT systems in Europe after the LSP execution,
  - Show and demonstrate advanced results obtained during the pilot deployment and execution (substantial savings, easy deployment for examples) in order to facilitate acceptance in the market.

4.2.4 Methodology for the testing of business models

Business models should be tested in real scenarios with an iterative methodology. The following steps are recommended:

1) Agree with stakeholders about their business goals, and identify together some measurable Key Performance Indicators (KPI) that can be affected by the adoption of the solution and that can be used to assess the impact of the system, for instance:
   - Increasing sustainability of 5% in the traditional market,
   - Adding or moving to a new market segment, like the organic one,

   - Increasing customer satisfaction of 10% through usage of smart label,
   - Etc.
2) Review the business model during the pilot phase and adjust the business goals,
3) Measure the KPIs, review the business results at the end of the pilot and fix the new goals.

The same methodology can be used by the IoT providers to check their business models.

4.3 Recommendations for the testing of user acceptability

4.3.1 Recommendations

Even if the notion of "user" can be different through the global agri-food value chain (food manufacturer, retailer, consumer, policy maker, local authority, etc.), farmers are the main concern regarding acceptability.

Three types of acceptability could be considered:

- **Business acceptability** as seen above (see recommendations in section 4.2.3),
- **Technology acceptability**: smart technologies in the agri-food chain mean bringing closer two different worlds, the digital and physical ones. The adoption of smart technologies, especially for farmers, is a key element.
- **Social acceptability**: in order to be compliant with environmental requirements, rural development needs, gender issues and inclusion best practices.

In 2010, 71% of EU farm managers were still operating on the basis of practical experience[6]. The adoption of smart technologies may be long for non-technophile farmers. Some farmers in remote rural areas have no access or low band access to Internet, not much wireless coverage and are not aware of new technologies. They believe that they don't need this kind of enhancement for their daily job and they don't have time to learn. They also want to be sure that data is used to add value to their products in the eyes of consumers and with a real service behind.
Moreover, current systems already used by modern farmers still have significant drawbacks, in particular in terms of flexibility, efficiency, interoperability, robustness, high operator cost and capital investment.

For farmer's acceptability, the main recommendations are:

- Take into account the difference of digital maturity between farmers, especially regarding rural wireless and broadband access,
- Identify early-adopters so they can demonstrate the solutions acceptability, with the possible help of associations and local authorities,
- Involve users from the very beginning: definition of the business processes to be supported, ideation of the future scenarios to be reached by the adoption of the solution, identification and prioritisation of requirements, etc. Generalisation of the processes and requirements identified in the LSP will be critical to ensure the general validity and applicability of the solutions.
- Ensure alignment of views between users and solutions providers: clear explanations of the offer, intermediate and incremental prototypes, visual mock-ups, etc.
- Take specific care of data security and privacy to build trust,
- Propose user-friendly solutions, easiness of interpretation of outputs and data, straightforward and useful information,
- Improve cross-over between emerging technologies and the more specific farming sector and their practical needs, ensuring that the technical solutions work properly in real conditions,
- Include education and training aspects, especially in integrating initiatives already running and academic partners into this process,
- Adapt and simplify communication.

[6] https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/09.%20SC2_2016-2017_pre-publication.pdf (p.145)

4.3.2 Methodology for the testing of user acceptability

A list of measurable objectives can be decided with the user at the beginning of the pilot, to be reached at the end of each phase and at the end of the full implementation of the solution.
For instance:

- The user is able to understand and use at least 75% of the solution basic features,
- The user can use the tool as a DSS (Decision Support System) for his business,
- The user can reach at least 50% of his business goal using the tool (for example if the goal is saving 50% of pesticides costs, user should be able to save at least 25% of those costs),
- Exact type of data to be used for data aggregation for premium services is identified.

Technical testing conducted with the users will measure the completeness and correctness of the solution. Non-technical testing will focus on measuring the usability/acceptability of the solution and will be conducted in direct interaction with the stakeholders involved in the testing, collecting their subjective/personal feedback.

Generalisation of the results across the LSP will be fundamental.

5 Investigation of the operational dimension for the large scale pilot

It is expected that the LSP will bring together a large number of entities coming from a wide variety of domains both on the IoT supply side (hardware manufacturers, telecom operators) and in the IoT demand side (farmers, machinery manufacturers, food processing plants, distribution and retail companies, and consumers, to name a few), as well as research technology organisations and universities, which could may belong to either side.

It is also expected that the LSP would integrate a number of individual pilots, dealing with particular application cases, possibly based in different locations across Europe, and involving (not necessarily only) local partners.

Recommendations:

- ➢ The LSP should involve a comprehensive representation of stakeholders both from the IoT supply side and the demand side. It is strongly encouraged to follow a multi-actor approach.[7]
- ➢ Each of the pilots integrating the LSP should consider the engagement of several local stakeholders involve in order to maximize the engagement during the pilot and the future sustainability.
- ➢ [Use-case coverage] The LSP should cover a meaningful number of application cases that are relevant for the farming and/or food safety domains in Europe.
- ➢ [Geographical coverage] The LSP should guarantee a wide geographical coverage across Europe.
- ➢ [Validation] The LSP must be tested during a significant period of time in order to demonstrate meaningful benefits and its adaptability for replication.
- ➢ The LSP should include specific and realistic quantified indicators to monitor progress at different stages during the implementation
- ➢ In the case of smart farming, the LSP should consider non-intrusive IoT technologies or demonstrate they do not affect to animal life.

Appropriate governance and social innovation models are required for the success of the Smart Farming LSP: EIP Agri & EIP Water both states the need for innovative Governance Models to really align and synchronise efforts of all the actors in the value chain.

The absence of effective and efficient Governance Models conform a barrier to tackle real technology transfer processes and commercialisation of innovative solutions, inhibiting offer and demand to meet in a profitable way and the promotion of Public Private People Partnerships to reach sustainable and policy

[7] Details on the multi-actor approach are given in Section 2.2 of this document.

industry impact. Governance Models need to be deployed and refined where all actors meet, cooperate and interact, embracing new IoT solutions to promote society behaviours' changes and awareness.

5.1 Governance of the consortium

Different dimensions of the governance are envisaged:

1) Pilot-wise organisation: two-level governance

- A governance body at full LSP level, in charge of monitoring the implementation of the individual pilots, among other possible responsibilities.
- A governance body at the level of each individual pilot, in charge of managing the pilot, able to represent the individual pilot and the partners involved in it and liable before the LSP governance body.

2) IoT Supply-Demand governance. To facilitate the exchanges between both sides. This body should integrate a representation of the full consortium, and coordinate some of the cross-cutting activities dealt within the LSP, collection of demand-side requirements, training activities, business models, end-user acceptability. This governance body should encompass at least one Project Innovation Manager, in charge of keeping aligned developments internal to the project with external demands.

Coordination/interaction among LSPs
It is expected that a number of parallel LSPs will be funded through the next H2020 ICT call under the IoT Focus Area, each covering different vertical market domains. The LSP should be prepared to share information and cooperate with other LSP, in particular to define and adopt a common infrastructure methodology. The LSP on Smart Farming and Food Safety should allocate the necessary resources to allow for a proper interface with the rest of LSPs, and the CSA supporting the implementation of the LSPs.

The purpose of such interactions is manifold: benchmarking and mapping of the pilots and the technologies implemented, result synergies, inputs for policy-making, awareness, identification of success stories, etc.

5.2 Facilitating collaboration

It is expected that the heterogeneous nature of all the actors involved in the LSP may pose some difficulties when it comes to collaboration. The LSP should take the necessary measures to break such barriers. (One possible solution is the design of a proper governance such as the one described above).

In order to reduce collaboration barriers the LSP should contribute to the improvement of the multi-check points over the value chains ensuring reliability in the whole process and thus between parties involved.

Clear rules regarding data usage and data ownership should be defined to prevent abusive behaviours from stakeholders, and thus favour adoption of IoT solutions in smart farming & food safety.

Intellectual Property
As it has been underlined previously in this document, the business cases arising from the application of IoT to the fields of smart farming and food safety are likely to involve added value and intellectual property coming from a number of technology and service providers. It is expected that the actors involved in a business case will be eager to explore innovative models for joint IP exploitation when required.

The pilots should clearly show how these IP-related aspects are accounted for in the proposed business cases. Also, when new intellectual property results arise from the implementation of the pilot, a proper plan for exploitation of the results should be established upfront (although later during the pilot execution it

could suffer some modifications).
Socio-economic impact and target groups for the results of the LSP should be considered. If patents, trademarks, registered designs, etc. are expected should be also listed. For patent applications, only if applicable, contributions to standards should be specified.

5.3 Sustainability of the pilot beyond the funding period

One key element to the sustainability of the solutions implemented in the LSP is the identification of proper business viability conditions. The validation phase should provide socio-economic evidence for ICT investments in the field, including return of investment and user acceptance. Recommendation: LSP should include detailed plans for sustainability after the LSP funded period.

Synergies with other (co)funding sources should be seen a strength whenever it can be proven that there is no overlap but actual complementarities. This applies for example to Structural Funds such as the EAFRD, ERDF or interregional funds, typically managed at national or regional levels.

Synergies with related initiatives or programmes expected to survive the LSP should be seen as a strength.

Referring to initiatives or programmes expected to survive the LSP, we can consider the Knowledge and Innovation Community on Food [24] that will be launched by the EIT (European Institute on Innovation & Technology) by the end of 2016. We can also consider the activation of an Open Call, with the aim to assign part of the Project funding to external actors interested in exploiting solutions implemented in the LSP and building new business opportunities.
Actors will be in charge of the solution's maintenance for a given period beyond the LSP funding period.

Sustainability of the pilot can be also ensured by timely engaging in the project committed stakeholders that are due to continue the pilot beyond the funding period. Stakeholders involved in the project can carry on successful LSPs beyond the funding period, provided that they are able to demonstrate their strong commitment by presenting a solid and convincing cases including, for example, a business plan developed independently from the project.

6 Next steps

The adoption of IoT in the smart farming and food safety sectors will greatly benefit from proper awareness actions, which could encompass additionally training or education activities as the market of technologies and services starts gaining momentum.

AIOTI WG06 foresees to perform awareness efforts starting from Q4 2015 targeting the end-user community (farming sector, food processors, etc.). Such awareness raising actions should possibly be co-located with already existing events that gather the target community.

List of already identified events

- 7th European Conference on Precision Livestock Farming (EC-PLF), 15-18 September 2015, Milan, Italy. http://users.unimi.it/ecplf2015/
- VI International Conference on Landscape and Urban Horticulture, 20 – 25 June 2016, Athens, http://www.ishs.org/symposium/367

Possible events for dissemination may be found here (to be decided, suggestions welcome):

- Meetings EIP-AGRI Focus Group Precision Farming: https://ec.europa.eu/eip/agriculture/en/content/seminars

- General events oriented to the Farming Sector: https://ec.europa.eu/eip/agriculture/en/news-events/events/european-calendar
- Events listed in the ERA-NET ICT Agri website: http://www.ict-agri.eu/events

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8 Annex 1: Table of existing initiatives in smart farming and food safety

				Domain / application case coverage								
Initiative	**Type**	**Website**	**Short description**	**Geographical coverage**	**Plant Farming**	**Livestock farming**	**Food processing**	**Logistics**	**Retail**	**Food safety / health / traceability**	**Consumer**	**Available TRL (if exists)**
Partnerships and Technology Platforms												
EIP-Agri - Precision Farming	EIP focus group	http://ec.europa.eu/eip/agriculture/en/content/mainstreaming-precision-farming		EU	X	X				X		
ERA-NETs ICT Agri 1, ICT Agri 2	ERA-NET projects	http://www.ict-agri.eu/		EU	X	X						
European Technology Platform Food for Life	ETP	http://etp.fooddrinkeurope.eu/asp/index.asp		EU			X	X	X	X	X	
TP Organics	ETP	http://www.tporganics.eu/	TP Organics is the European Technology Platform for organic food and farming research. It integrates views of the organic sector and civil society to represent a broad perspective on research and development priorities that can leverage organic food and farming's potential to address contemporary	EU	X	X	X			X		

			challenges.										
WssTP	H2020 project	http://wsstp.eu/	WssTP is the European Water Supply and Sanitation Technology Platform.	EI	X								
AEF (Agricultural Industry Electronics Foundation)		http://www.aef-online.org/	AEF is a no-profit association made by 8 core member companies and more than 140 standard member companies from the AG sector. All of them are working together in improving and prototyping technologies for the in-farm and in-field activities such as high voltage, ISOBUS automation, wireless communication, FMIS data exchange and so on).	EU, America	X	X							
Existing products, services													
FoodLoop	Product	https://www.foodloop.net/	FoodLoop's Retailer Platform ties grocer inventory system to consumer-facing mobile apps to provide real-time deals and personalized offers based on consumers' interests, purchase history, and location						X		X	
SmartVineyard	Product	http://smartvineyard.com/home/	Precision viticulture technology for grape disease monitoring. SmartVineyard helps optimizing pesticide output by providing accurate data on diseases.		X								
DairyMaster	Product	http://www.dairymaster.com/heat-detection/	Heat detection system to allow farmers to monitor their herds remotely to assess health, and fertility issues of cows.			X							
365FarmNet	Product	https://www.365farmnet.com/en/	SaaS which enables farmers to manage their entire agricultural holding with a single software.		X	X		X					
Projects													
SmartAgriFood	FP7 project	http://www.smartag	The SmartAgriFood project is part of the Future Internet Public-Private	EU	X	X		X					

	(FI-WARE based)	rifood.eu/	Partnership (FI-PPP) program and addresses Farm management, agri-logistics and food awareness as a use case for this. Data collected from local sensors in the farms (IoT), tractors and machineries smart devices and other sources (e.g. satellite and -remote -sensing technology) converge in the cloud platform (FIWARE) enabling information & decision support systems. Such systems improve the smart agri-food production system efficiency, performance and sustainability, considering all its elements as a whole:									
FIspace	FP7 project (FI-WARE based)	http://fispace.eu/	FIspace is a business-to-business (B2B) collaboration platform. It works like a social network, like LinkedIn or Facebook. Once registered, contacting affiliates is simple, secure and easy. Focused on agriculture	EU				X				
Finest		http://www.finest-ppp.eu/	The ultimate aim of the FInest project is to develop a Future Internet enabled ICT platform for better supporting and optimizing the collaboration and integration within international transport and logistics business networks. This shall be realized as a domain-specific extension of the FI PPP Core Platform	EU				X				
FIWARE project: FRACTALS	FP7 project	http://fractals-fp7.com/	3rd phase accelerator, focused on agriculture	EU	X			X		X	X	
FINISH	FP7 project	http://www.finish-project.eu/	3rd phase accelerator, focused on agriculture	EU	X		X	X		X		

QUHOMA	FP7 project	http://quhoma.com/	QUHOMA is one of the projects funded by Fiware-Finish accelerator project in the agri-food domain. The project aims to set a data-centred FIWARE/SPACE B2B Marketplace for the efficient cultivation and effective market launch of qualitative agri-products.	EU	X					X		7-8
EFFIDRIP	FP7 project	http://effidrip.eu/	Kit of web platform + data-acquisition hardware (IoT modules) for allowing SME offer services of smart irrigation supervision and control. The project demonstrated the technical feasibility of unmanned precise control of irrigation during a whole season, which overperformed manual operation by a human expert. Pilot plots operated during 2013 and 2014 in Spain, Portugal and Greece.	EU								
agriXchange	FP7 project	http://www.agrixchange.org/	agriXchange is an EU-funded coordination and support action to setup a network for developing a system for common data exchange in the agricultural sector.	EU	X	X						
sigAGROasesor	LIFE project	http://agroasesor.es/en/	sigAGROasesor aims to develop and refine a series of DSTs for extensive agriculture. A web platform has been developed, offering on-line services to farmers, aiming at allowing them to work more efficiently, effectively and competitively yet always in line with environmental and social sustainability.	ES	X							

LIFE AGROintegra	LIFE project	http://www.agrointegra.eu/en/	The overall objective is to minimize environmental risks in crop protection of cereals, vegetables, fruit trees and vineyard, through the demonstration of the feasibility of more sustainable alternatives for pests, diseases and weeds control. Within this project a collaborative pests monitoring a warning system is being implemented, in which different users (farmers, technicians etc) will share data for the common benefit.	ES	X							
Precision Livestock Farming (PLF)	FP7 project	http://www.eu-plf.eu/	EU-PLF is an FP7 project funded by the European Union that aims to translate research results for PLF into a practical blueprint that benefits the animal, farmer, environment and consumer. It is a four-year project that began in November 2012 and is executed by 21 research, industrial and business partners	EU		X						
ALL-SMART-PIGS	FP7 project	http://www.all-smart-pigs.org/	The EU funded ALL-SMART-PIGS was an EU-funded project aiming at demonstrating the viability of smart farming technologies in European pig farming. The project used a process of open innovation through a LivingLab to co-create smart farming applications ready for commercialisation on European pig farms. These applications were provided by innovative SMEs which in ALL-SMART-PIGS tested and validated their technological prototypes and services in real life conditions together with pig farmers and other stakeholders.	EU		X						

MUSETECH	FP7 project	https://www.musetech.eu/	The concept of MUSE-Tech project is the integration of three High-End sensing technologies (Photoacoustic Spectroscopy, Quasi Imaging UV-Vis Spectrometry and Distributed Temperature Sensing) in a versatile Multi Sensor Device (MSD), for real-time monitoring (on-line or in-line) of multiple parameters associated with the quality and the chemical safety of raw and in-process materials.	EU			X			X		
Prometheus	FP7	http://processing-contaminants-prometheus.com/	On-line techniques to monitor reactions leading to contaminant formation, demonstration at industry level.	EU			X			X		
Optimalt	FP7 SME	http://cordis.europa.eu/result/rcn/56490_en.html	Optical inspection techniques to predict malt quality & safety	EU			X			X		
Mycospec	FP7	http://mycospec.eu/	Develop an innovative tool based on infrared spectroscopic fingerprinting techniques for rapid on-site mycotoxin detection in food crops and processed foods	EU			X			X		
OTAsens	FP7-SME	http://cordis.europa.eu/result/rcn/58301_en.html	Detection and quantification of OTA in wine, beer and feed, through a linear array of photosensors.	EU	X		X			X		
IrriSens (RTA2013-00045-C04)	INIA (Spanish Ministry of Agric.)		Focuses in the unmanned interpretation of sensor data (IoT) in the context of irrigation and their usage in automated supervision and control. Uses Artificial Intelligence approaches to cope with issues such as seasonal strategies, management	Spain	X							

			of fertigation and spatial heterogeneity. Pilot plots in 2016 and 2017.									
IQ-FRESHLABEL	FP7 project	http://www.iq-freshlabel.eu/		EU								
WaterInnEU	H2020 project	http://www.waterinneu.org/	WaterInnEU's primary vision is to create a marketplace to enhance the exploitation of EU funded ICT models, tools, protocols and policy briefs related to water and to establish suitable conditions for new market opportunities based on these offerings.									
PigWise	FP7 project	https://ec.europa.eu/eip/agriculture/en/content/pigwise	PigWise was a ICT-AGRI multi-disciplinary project whose objective was to optimize performance, monitor the growth and welfare of fattening pigs exploiting High Frequent Radio Frequency Identification (HF RFID), camera vision technologies and a newly developed IT tool based on a middleware infrastructure. Such ICT solution allows detecting problems in the early stage, supporting specific decisions and preventing economic losses.	EU		X						
ebbits	FP7 project	http://www.ebbits-project.eu	The ebbits project aimed to develop architecture, technologies and processes, which allow businesses to semantically integrate the IoT into mainstream enterprise systems. The ebbits solution has been demonstrated in end-to-end business applications featuring on-line monitoring of a product in its entire lifecycle. ebbits has focused on food traceability from farm to fork	EU						X	X	

			bringing added value for consumers and companies. ebbits has further developed the solution to support companies' needs in more complex supply networks, including not only vertical but also horizontal value chains.									

9 Annex 2: Examples of use cases

		Relevance criteria					
Application case	**Domain(s) of application***	**Economic relevance of the application domain (0: not relevant; 5: most relevant)**	**Pre-identified benefits of this application case (e.g., operational efficiency/profitability/regulatory compliance / safety…)**	**Ecological impact: (e.g., reduces waste, carbon footprint, chemicals)**	**Geographical impact (EU regions potentially involved)**	**Involves several phases of the "from farm to fork" chain (If yes, which ones)**	**Has it already been tested (If yes, indicate the project, initiative, product…)**
Water/irrigation management	PF, PF-OF	4 (varies locally with the price of water, type of crop, etc.)	Improvement in the Kg of yield per m3 of consumed water Makes irrigation setups more reliable and labour and energy-efficient	Reduces regional water consumption and transfer of nitrate and pesticides to ground water	Mostly southern Europe but growing interest elsewhere	Basically involves one phase: primary production. Provides data for calculating water footprint	Yes (e.g. EFFIDRIP)
Optimization of treatments, pest/disease control	PF, LF, PF-OF, LF-OF						
Waste management and waste re-use	PF, LF, PF-OF, LF-OF, FP						
Improvement of health and welfare status in animals	LF, LF-OF	LF-D (4) LF-Welfare (4)	LF-D (5) LF-Welfare (Profitability/Productivity; Regulatory compliance; Ethical impact of production system)	LF-D (3) LF-Welfare (Better production efficiency, i.e. reduction of carbon footprint)	LF-D (5) LF-Welfare (Global geographical impact – all EU and international)	LF-D (NO) LF-Welfare (YES: Production, Meat quality, Ethical quality of meat)	LF-D (Partially) LF-Welfare (YES: All Smart Pigs Project and EU PLF)
Monitoring of environmental conditions through sensors: temperature, humidity, lightness, water consumption…)	PF, LF, PF-OF, LF-OF	LF-D (4)	LF-D (4)	LF-D (3)	LF-D (4)	LF-D (NO)	LF-D (Partially)
Disease management	LF, LF-OF	LF-D (4)	LF-D (4)	LF-D (3)	LF-D (5)	LF-D (NO)	LF-D (Partially)
Precision feeding	LF	LF-D (5) LF-Welfare (4)	LF-D (5) LF-Welfare	LF-D (5) LF-Welfare (Better	LF-D (5) LF-Welfare	LF-D (NO)	LF-D (Partially)

			(Profitability/Productivity)	production efficiency, i.e. reduction of carbon footprint)	(Global geographical impact – all EU and international)		LF-Welfare (YES, in All Smart Pigs, EU PLF, ALIPREC (National Spanish Projects)
Monitoring of production and animal growing phases	LF						
Stock traceability	PF, LF, FP, D, WS, R						
Integrate relevant information from providers and customers to optimize production, logistics, etc.	FP, D						
Provide certification in the products to improve the commercial sales	PF/LF, FP, D, WS, R						
Smart detection of fraud or substitution in products	PF/LF, FP, D, WS, R						
Organic certification up to the consumer	PF-OF, LF-OF						
Smart human nutrition (food & health)	C						
Improvement of food safety in the retail-to-fork part of the food chain, especially at home	WS, R, C	4	Consumer health	Reduction of food wastes	Global, worldwide	Retail-to-fork phases	Partially, basic technology available
Effective monitoring and management of residue and contaminants in the food/feed chain	PF, LF, FP, D, WS, R	5	Consumer health, food process efficiency, regulatory compliance, Food defence	Reduction of food wastes	Global, worldwide	All the phases	Partially, basic technology available

*Plants farming (PF); Arable crops (e.g. cereals, potatoes) – (PF-AC); Horticulture (e.g. fruits, vegetables) – (PF-HC); Urban Horticulture – (PF-UHC); Permanent crops (e.g. olive, wine) – (PF-PC); Organic farming – (PF-OF); Conventional farming – (PF-CF)
Livestock farming (LF); Meat production: beef (LF-B); Meat production: pork (LF-P); Meat production: poultry (LF-P); Dairy production (LF-D); Organic farming – (LF-OF); Conventional farming – (LF-CF)
Food processing (from raw material to food product) – (FP); Distribution (D); Wholesale (WS) & Retail (R); Consumer (C)