D5.2 Revised Stakeholder Requirements, Pilots Design, and Specification

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1 Executive Summary

To achieve a long-lasting and sustainable impact, all DEMETER project activities are closely tied to real world agricultural use cases in the 20 DEMETER pilots across 18 European Countries. The pilots are grouped into 5 thematic clusters:

- Arable Crops: Water + Energy Management
- Arable Crops: Agricultural Machinery, Precision Farming
- Fruits and Vegetables: Healthy and High-Quality Crops
- Livestock: Animal Health, High Quality & Optimal Management of Animal Products
- Cross-Sectorial: Full Supply Chain, Interoperability, Robotics

Working with the pilots, DEMETER addresses the following 5 key challenges:

- Farmers should be in control of the knowledge and be able to extract insight from it.
- Deployment models must accommodate existing investments.
- Good data analysis requires larger data sets – and is an opportunity for sharing data while keeping the farmers fully in control of their rights on the data they generate.
- Overcoming market barriers by creating an innovative ecosystem for SMEs and entrepreneurs.
- Interoperability and adoption of technological standards are key to link existing systems, enable future enhancements and expand the ecosystem.

These challenges have been translated into objectives and key performance indicators (KPIs), which are described in more detail in chapter 5. The combination of challenges, objectives and KPIs serves as major guideline for the development of the pilots and related activities.

Whilst the overall objectives and challenges ensure that the final results of DEMETER will have a sustainable impact on the agricultural communities in Europe, understanding the individual stakeholders and needs in the DEMETER pilots is key to ensuring that these results are of relevance and good use to farmers in real life.

The approach taken to identify stakeholders, their roles and requirements is described in detail in chapter 6. It is based on input collection through standardised questionnaire templates, refined through discussions in online conferences and bi-lateral interviews.

The starting point was D5.1, delivered in project month 2, which provided a collection of relevant information that would be needed to start all Work Packages' (WPs) activities in DEMETER. Each WP contributed its initial input requirements to a consolidated common questionnaire, which has been used as a template to collect the necessary information from the pilots' representatives. At that early stage the focus was mainly on two main areas:

- A narrative description of the pilots' current situation, the respective challenges and the envisioned scenario toward the end of DEMETER.
- An inventory of software, hardware, data, standards and technology frameworks to be considered in the DEMETER activities.

The identification of detailed business requirements and external stakeholders was not yet possible in month 2. To fully identify business requirements, an iterative analysis and communication process with the pilots, and eventually with external stakeholders is part of the DEMETER MAA approach. As a starting point in month 2, the roles and requirements of partners directly involved in the pilots were identified and used to develop a methodology for follow on work on this important cross WP topic.

The overall results of the initial collection round were documented in D5.1 and deemed appropriate input to the technical WP to start their respective work items. The derived baseline for technical concepts and approaches was further refined through additional specific questionnaires and bi-lateral discussions between individual pilots and the technical WPs as needed. Abstracting the collected input into architectural concerns, concepts and DEMETER components was carried out in the WPs 2, 3 and 4 and is documented in their respective deliverables.

The information collected with this approach has been refined in a second iteration cycle and summarized in this report. Detailed descriptions of each cluster and all pilots provide information about the current situation and challenges, the foreseen goal at the end of the project and how the objectives of DEMETER will be addressed. The initially identified technology requirements, assets and data sources listed in the Annexes to this document have been updated and are further used and refined during the Pilot Round 1 execution.

The maturing understanding of the pilots and their environments is moving the stakeholder identification from looking at involved partners to abstracted stakeholders with generic roles and interest. Instead of the initial diagrams outlining the pilots' partners and their basic relationships and interest, the pilot descriptions now include an initial high-level mapping of the pilots' stakeholders, their roles and their main interests.

The identified soft- and hardware components, data sources, standards etc. which provide input to the pilot design, specification and planning process in cooperation with other DEMETER WPs are maintained as separate Annexes to this report. Once dedicated deliverables documenting the final implementation details of the pilots become available, the technical Annexes to this report might be moved to the respective reports.

2 Acronyms

AI	Artificial Intelligence
API	Application Programming Interface
CoAP	Constrained Application Protocol
COTS	Commercial of the Shelf
DSS	Decision Support System
dt	Deci tonne (100kg)
EO	Earth Observations
FADN	Farm Accountancy Data Network
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FMIS	Farming Management Information Systems
ha	Hectare
HW	Hardware
ICT	Information and Communications Technology
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
IoT	Internet of Things
KPI	Key Performance Indicators
LED	Light Emitting Diode
LFA	Less-Favoured Areas
MAA	Multi Actor Approach
NDMI	Normalized Difference Moisture Index
NGSI / NGSI-LD	Context Information Management Protocols
NPK	Nitrogen, Phosphorus, and Potassium Fertilizer
ML	Machine Learning
KPI	Key Performance Indicators
MQTT	Message Queuing Telemetry Transport Network Protocol
NDVI	Normalized Difference Vegetation Index
NUTS	Nomenclature of Territorial Units for Statistics
UAV	Unmanned Airborne Vehicle (e.g. Drones)
PEMS	Portable Emission Measurement Systems
REST	Representational State Transfer
SOAP	Simple Object Access Protocol
SOCS	Stakeholders Open Collaboration Space
SQuaRE	Software product Quality Requirements and Evaluation
SW	Software
UC#	Use Case
VRA	Variable Rate Application (e.g. of fertiliser or pest treatments)
WFS	Web Feature Service Standard of the Open Geospatial Consortium
WIG	WatchITgrow platform
WMS	Web Mapping Service Standard of the Open Geospatial Consortium
WP	Work Package

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4 Introduction

This report summarizes the results of identifying the key stakeholders of the DEMETER Pilots and their requirements. It provides a summary of the current status and expected benefits of the DEMETER pilots at project month 9. The preceding report D5.1 was compiled in month 2 and carried out a first assessment of the DEMETER pilots. The focus was on two aspects:

- A requirements study that identified stakeholders and their roles and interests.
- The collection of available data, data models, data management and sharing principles, communication technologies including protocols and interfaces, interoperability arrangements, the use of standards, and the integration of data produced on farm with externally provided data.

The scope and objectives of this updated report remain largely the same. However, in this document all main document sections have seen major updates since it now reflects the work carried out on the initial requirements between the pilots and the DEMETER technical Work Packages' (WPs) 2, 3 and 4. An overarching desire of all pilots are decision support components. The technical WPs have clustered the decision support requirements of the individual pilots into the following areas of common interests:

- Crop Growth, Status and Yield
- Irrigation Management
- Nutrition Management
- Machinery
- Pest and Disease Management
- Animal Growth
- Animal Welfare
- Traceability
- Benchmarking
- Marketing
- Interoperability
- Regulation

A detailed mapping of pilots to the resulting WP2, 3 and 4 components is provided in Annex 5 of *D5.3 Testbed Deployment, System Extensions and Applications for Pilot Round 1.*

Workshops between the technical WPs and the pilots were used to ensure that all pilots are aware of mandatory and optional DEMETER enablers, components and services. Doing this at the start of the pilot implementation activities ensured a common picture among the pilots about available building blocks, thus reducing the risk of duplicating efforts on similar requirements. At the same time the exercise triggered first ideas about cross pilot fertilisation and possibilities to transfer approaches to alternative application areas. An example is the development of automated fruit fly detection in Pilot 3.3 for orange groves: whilst adapting the system to other crops, such as olives in Pilot 3.1, seems to be an obvious opportunity, discussions with Pilot 5.3 have started to also consider the application for the identification of varroa mites in beehives. Likewise, the application and integration of pollination services with other arable crop pilots is being discussed. The results of these activities will be presented in the final iteration (D5.4) of this report in April 2021.

This report also presents a revised understanding of the stakeholder roles and how they impact DEMETER, driven by WP7. As the project progresses, the understanding of potentially involved stakeholders, their roles and expectations has significantly matured. In a joint effort, WP5 and WP7 developed a more generalised approach to ensure that dissemination, exploitation and community building activities can better target the stakeholder communities of interest, as part of the DEMETER Multi Actor Approach (MAA) in WP7, as well as through dissemination and exploitation activities in WP6.

As the pilots are preparing for the first round of DEMETER implementations, the narrative descriptions of the pilots, which form the core of this report, have been revised to reflect the current state.

The findings presented in this document are/will be complemented by the reports listed below, as they become available. Especially the specific translation and abstraction of the real-world requirements described in this report into architectural concerns, concepts and DEMETER components are described in the following WP 2, 3 and 4 deliverables:

- D3.1 / D3.3 DEMETER reference architecture (March 2020/March 2021)
- D2.2 DEMETER Data and Knowledge extraction tools (June 2020)
- D4.2 Decision Enablers, Advisory Support Tools and DEMETER Stakeholder Open Collaboration Space (June 2020)

The DEMETER Pilot Round 1 implementations starting in September 2020 will follow the plan and specifications documented in the following report:

- D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020)

With D5.3 the first iteration cycle of identifying the real-world user requirements, supporting their translation into technical requirements in the technical WPs and their related reports, and planning a first deployment in the pilots will be completed.

The final report (D5.4) on Stakeholder Requirements, Pilots Design, and Specification will become available in April 2021. In due course, some parts of this document (such as the listing of identified data, relevant software components etc.) will be moved to the DEMETER reports where they have the best fit and highest relation.

The following chapter 5 outlines the overall DEMETER challenges and objectives, chapter 6 describes the methodology applied to identify stakeholders, their interests and the interaction with the other DEMETER WPs. The main body of the document consists of the introduction to the DEMETER Clusters in chapter 7 and the detailed description of the Pilots in chapter 8, and concludes with a brief outlook on next steps in chapter 9. The annexes contain the asset listings of data, soft- and hardware, standards etc.

5 The DEMETER Challenges and Objectives

DEMETER identified 5 key challenges and formulated 6 key objectives to guide the project activities. As part of the pilot stakeholder identification and requirements collection, each pilot was also tasked to state its contributions to address the challenges and objectives.

5.1 The DEMETER Challenges

5.1.1 Challenge #1 – Control of Knowledge

they can obtain from the data relevant to their specific requirements and activities, i.e. moving from the present situation, in which farmers can be overwhelmed by the shear amount of data, to one in which they benefit from the insights of that data.

5.1.2 Challenge #2 – Deployment Models

A context where the lifespan of agricultural technology extends in some cases over 20+ years requires solutions and innovations to be deployed over existing machines. Protecting the existing investments made by farmers while making them part of a digitally enriched environment is a major driver for DEMETER.

5.1.3 Challenge #3 – Optimal Data Analysis

For useful trends and patterns to emerge, there is a need to work on large sets of data obtained across multiple farms. A key transformation resides in the ability to collect more data and measurements about the production: soil quality, irrigation levels, weather, presence of insects and pests, etc. In this context, reaping the full value of data requires the creation of trusted cooperation spaces in which data can be collected and shared, taking into account conflicting interests, competition etc. But this is also an opportunity of putting the farmers fully in control of their rights on the data they generate.

5.1.4 Challenge #4 – Overcoming Market Barriers

Large players have aimed, early on, to establish themselves in dominant positions through supplier-operated technological and data platforms. Effectively increasing the lock-in of farmers to a single or a selected group of suppliers and limiting their access to innovation. The challenge is in creating an innovative ecosystem for SMEs and entrepreneur.

5.1.5 Challenge #5 – Interoperability

Interoperability and adoption of technological standards are key to ensure compatibility and to support data exchange and standardised communication that links the different systems together in a unified system covering all aspects of the agricultural exploitation.

5.2 The DEMETER Objectives

Based on the identified challenges, DEMETER defined 6 objectives to empower farmers and farmer cooperatives to

- better exploit their existing operational context, i.e. the platforms, machinery, sensors they have, to extract new knowledge on which they can improve their decisions and
- ease the acquisition, evolution and update of their context by focusing their investments where these are needed, based on their goals measured by key performance indicators (KPIs) that they select.

5.2.1 Objective #1 – Information Modelling

Analyse, adopt, and enhance existing (and, if necessary, introduce new) Information Models in the agri-food sector, easing data sharing and interoperability across multiple Internet of Things (IoT) and Farming Management Information Systems (FMIS) and associated technologies. Use the information models to create a basis for trusted sharing / exposure of data between farmers.

The expected benefit is to enable a connection of different platforms, sensors, information sources and proprietary (to the farmer / cooperative) knowledge through a DEMETER services model. The primary beneficiaries will be ICT providers.

This objective addresses the challenges 1, 3 and 4, and will be an important aspect of *WP 2 – Data and Knowledge*.

5.2.2 Objective #2 – Knowledge Exchange Mechanisms

Build knowledge exchange mechanisms, delivering an Interoperability Space for the agri-food domain, presenting technologies and data from different vendors, ensuring their interoperability, and using (and enhancing) a core set of open standards (adopted across all agri-food deployments thereby) coupled with carefully-planned security and privacy protection mechanisms (also addressing business confidentiality).

The expected benefits are to:

- ease the deployment of novel solutions based on different platforms, sensors, information sources using the new information models from Objective 1,
- ease the uptake of future (not yet developed) services, data sources, technologies by farmers, with the Interoperability Space allowing the farmers and other relevant stakeholders to increase the range of choices for the most appropriate combination of tools from different suppliers in order to support their expected innovation, limiting the vendor lock-in, and
- allow the combination of existing systems / machinery with new technologies.

The primary beneficiaries will be ICT providers, technology providers and farmers.

This objective addresses the challenges 2 and 4 and will be an important aspect of *WP 2 – Data and Knowledge* and *WP 3 – Technology Integration.*

5.2.3 Objective #3 – Data Ownership

Empower the farmer, as a prosumer, to gain control in the data-food-chain by identifying and demonstrating a series of new IoT-based, data-driven, business models for profit, collaboration and co-production for farmers and across the value chain, leading to disruptive new value creation models.

This is expected to introduce the benefits of data ownership to farmers as a valuable source of income and knowledge sharing. The primary beneficiaries will be farmers, service advisors, ICT and technology providers.

This objective addresses the challenge 1 and will be an important aspect of WP 3 - Technology Integration, WP 4 - Performance Indicator Monitoring, Benchmarking and Decision Support, WP 6 - Business Modelling, Innovation Management, Exploitation and Standardisation and WP 7 - Multi-Actor Ecosystem Development.

5.2.4 Objective #4 – Benchmarking

Establish a benchmarking mechanism for agriculture solutions and business, targeting end-goals in terms of productivity and sustainability performance of farms, services, technologies, and practices based on a set of key performance indicators that are relevant to the farming community.

The expected benefit is to ease the comparison between competing services, machineries, sensors, platforms prior to acquisition. The primary beneficiaries will be advisory services providers and farmers.

This objective addresses the challenge 4 and will be an important aspect of WP 4 - Performance Indicator Monitoring, Benchmarking and Decision Support and WP 7 - Multi-Actor Ecosystem Development.

5.2.5 Objective #5 – User Orientated Solutions

Reverse the relationship with suppliers, through an innovative model in which suppliers are responsible for ensuring that a final solution is optimal to the farmer’s existing context and expressed needs.

The expected benefit is to ease the adoption of technologies by farmers, by decreasing the burden of the choices and clarifying the responsibility model, linked to needs and performance improvements defined by the farmers. They will be the primary beneficiaries.

This objective addresses the challenge 4 and will be an important aspect of WP 3 - Technology Integration, WP 4 - Performance Indicator Monitoring, Benchmarking and Decision Support, WP 6 - Business Modelling, Innovation Management, and WP 7 - Multi-Actor Ecosystem Development.

5.2.6 Objective #6 – Real World Impact

Demonstrate the impact of digital innovations across a variety of sectors and at European level.

The expected benefit is to ease and streamline mechanisms for all stakeholders, with clearly identified incentives to participate in a sustainable and value creation ecosystem. Structure collaboration channels in a security and privacy aware approach. This objective addresses all beneficiaries.

This objective addresses the challenge 1 and will be an important aspect of WP 6 - Business Modelling, Innovation Management, and WP 7 - Multi-Actor Ecosystem Development.

5.3 Impact and Success Criteria - KPIs

To measure the level to which the DEMETER objectives have been achieved, a number of key performance indicators (KPIs) have been established for each objective:

Objective #1 – Information Modelling Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented >= 50
	Number of solutions present in DEMETER >= 100
	Number of different suppliers involved in DEMETER >= 60
	Number of external components / data hubs connected to DEMETER >= 5
	New deployments at farmers >= 30 (see pilots and open calls)
	Number of harmonization’s and contributions to standards >= 10
	Volume of data observing the information models >=20 exa

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	available
New business models defined and adopted	available
Data exchange mechanisms implemented within DEMETER	Number of data exchanges (with financial retribution of farmers) >= 50
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements >= 500

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime >= 30
	Water and pesticide usage per yield unit and per hectare >= decrease on 15%
	Number of tools and datasets tried in pilots >= 5.000

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers >= 30
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed > 50.000

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER
	100 suppliers of solutions sign up to DEMETER
	Pilots deployed across 5 different sectors

A specific mapping of KPIs to pilot implementations will be addressed in the DEMETER deliverable *D5.3 - Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).*

6 Stakeholder Requirements Identification and Consolidation

DEMETER is a multi-actor project, which means achieving more demand-driven innovation through the effective and sufficient involvement of various actors throughout the project, from the participation in the planning of work, through the piloting/demonstration phase, to the dissemination of the results.

Since WP5 is the major hub for information flow from and to the pilots, the work and deliverables (such as this one) typically address two areas:

- The collection of the pilots' technical needs, validation and testing of proposed DEMETER concepts and components, and the demonstration and evaluation of results.
- The identification of internal and external stakeholders and their business requirements.

Within DEMETER the identification of requirements and assessment of proposed DEMETER solutions follows an iterative approach involving all WPs and the pilots as outlined below:

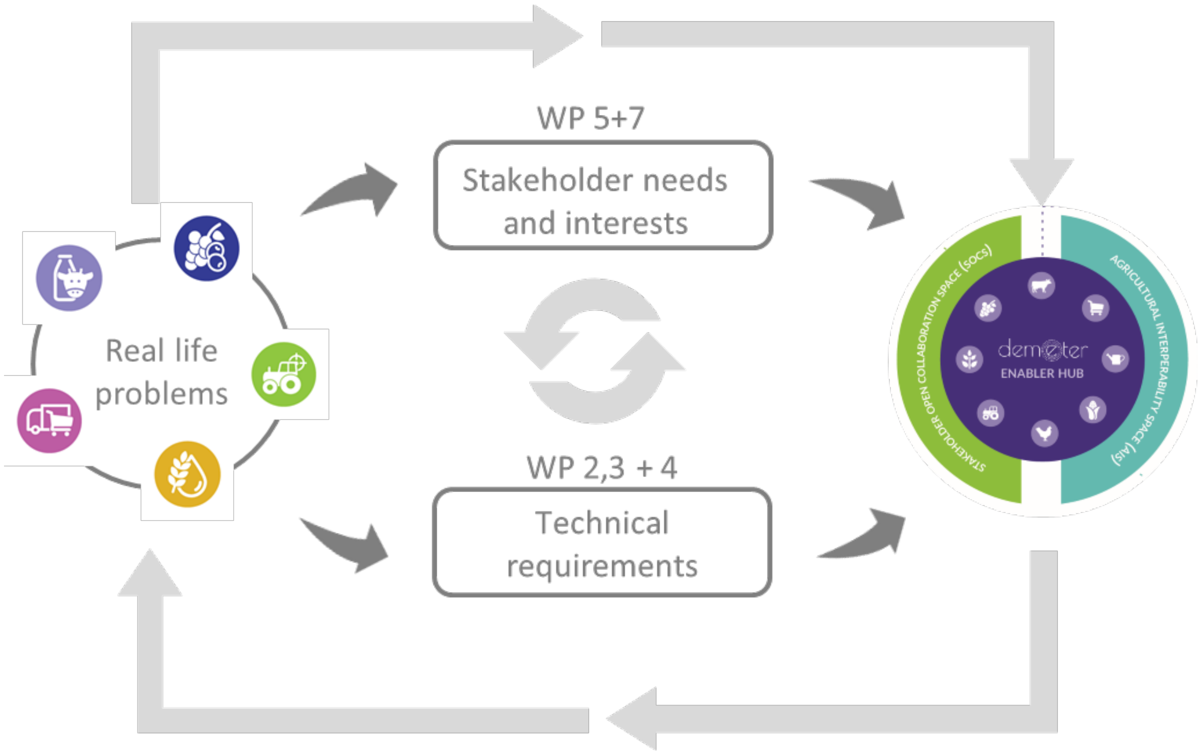

Figure 1: Iterative requirements collection and refinement process

The DEMETER Consortium, with its 60 partners and 20 pilots, already represents a broad spectrum of stakeholders and actors. In order to ensure a systematic and efficient approach for the successful implementation of the multi-actor concept, the methodology outlined in the following chapters was developed jointly with WP7 (multi actor ecosystem development).

6.1 Approach/Methodology

The identification of relevant stakeholders, and the collection and refinement of their requirements, follows an iterative approach, which involves not only the pilots, but also the technical WPs 2, 3 and 4, as well as the MAA, dissemination and exploitation WPs 6 and 7.

Whilst most activities are carried out in or through WP 5, the actual definition of input requests and interpretation of collected information are activities of the WPs 2-3-4 for technical aspects and WPs 6-7 for dissemination and exploitation MAA aspects.

The overall process is outlined below:

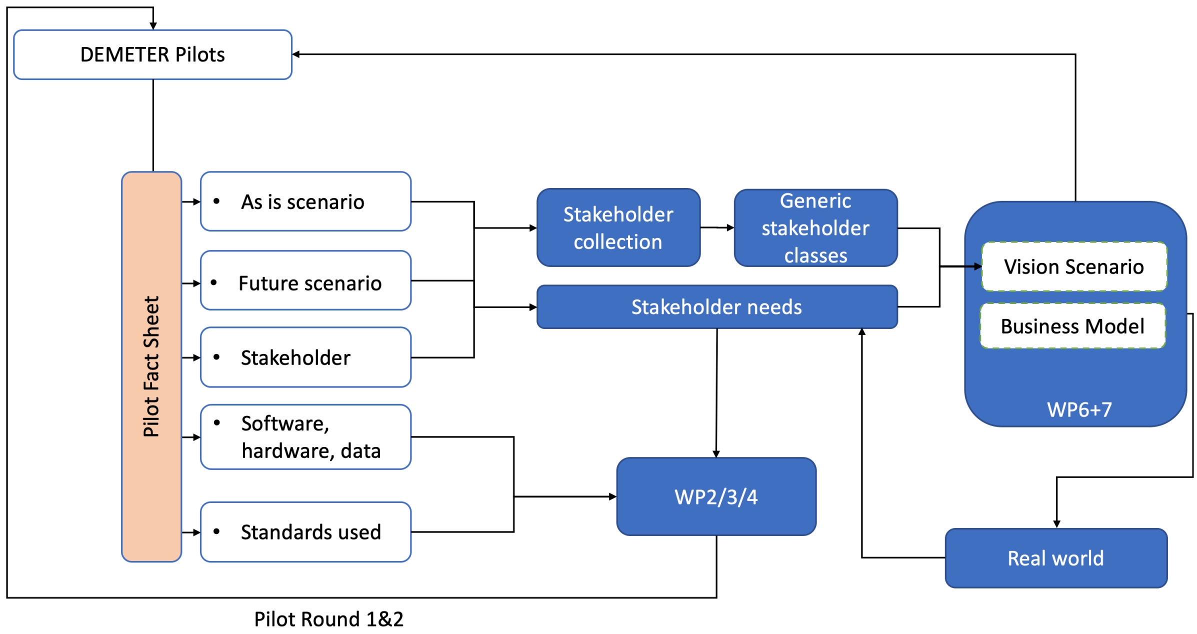

Figure 2: Stakeholder identification and analysis process diagram

The initial round of identifying the pilots' stakeholders and requirements was carried out during the first 2 months of the project. The primary objective at this early stage was to assess and document the pilots' use cases, their specific challenges and expectations, and to provide a common picture for the subsequent DEMETER activities.

To assess the pilots' technical capabilities and requirements, the starting point was a collection of all relevant information that would be needed to start all other WPs' activities in DEMETER. Each WP contributed its initial input requirements to a consolidated common questionnaire, which has been used as a template to collect the necessary information from the pilots' representatives. The templates used were agreed with WPs 2-3-4 to ensure that the information they need for further processing is captured. The main areas addressed were:

- A plain English narrative of what the pilot is about
- A description of the currently encountered challenge
- A description of the envisioned scenario and expected benefits
- The identification of stakeholders, their roles and requirements
- The identification of available and required assets, such as hardware, software, data etc.
- The identification of possible technology, ethical or legal constraints
- The identification of relevant standards

6.2 Identification of Technical Requirements

Within WP 5 these topics have been addressed by pilot representatives and the resulting information was documented in internal pilot fact sheets, which are based on the original questionnaire layout, but maintained as living documents to have a single place where relevant details can be updated or added. Information relevant to public DEMETER deliverables has been sourced from these factsheets.

The DEMETER technical requirements were then derived by the technical WPs from:

a. the pilots stated functional requirements,
b. DEMETER platform requirements proposed by partners,
c. the relevant technical assets brought in by partners or available as Commercial off the Shelf (COTS) and the requirements to support them, and
d. a State of the Art and standards analysis.

The requirements were evaluated at Task and WP levels and refined through a number of surveys, which have been carried out jointly by WPs 2, 3 and 4. The process was based on a common requirements template table (available in D3.2). The full process and survey descriptions and the consolidated results are documented in the following deliverables:

- *D2.1 - Common Data Models and Semantic Interoperability Mechanisms - Release 1*
- *D2.2 - DEMETER Data and Knowledge Extraction Tools*
- *D3.2 - DEMETER Technology Integration Tools - Release 1*
- *D4.1 - Decision Support, Benchmarking and Performance Indicator Monitoring Tools*
- *D4.2 - Decision Enablers, Advisory Support Tools and DEMETER Stakeholder Open Collaboration Space*

6.3 Identification of non-technical Requirements

A detailed identification of business requirements, but also environmental, policies, safety and user preferences, and external stakeholders was not yet possible in month 2. As a starting point, the roles and requirements of partners directly involved in the pilots were identified and used to develop a methodology for follow on work on this important cross WP topic. The resulting iterative analysis and communication process with the pilots, and eventually with external stakeholders, is part of the DEMETER MAA approach, and described in the following sections.

6.4 Identification of General Stakeholder Classes, their Roles and Interests

As mentioned before, D5.1 already contains a high-level description of the interests of stakeholders who are directly involved in the DEMETER pilots. In order to gain a better understanding of the stakeholders and their interests, and to ensure that the resulting insights can be applied to future users of DEMETER, the initial information has been updated and expanded by following three key questions:

- Which stakeholders will use the DEMETER platform in the future?
- Which interests motivate potential users to use the platform?
- But also, which concerns could lead to a negative attitude towards the DEMETER technology?

As a result, the initial heterogenous group of named parties could be consolidated into the following stakeholder classes of common interests:

Generic Stakeholder class	Definition
Farmer	This can be a single person, a cooperative or an association, engaged in agriculture, raising living organisms for food or raw materials.

Generic Stakeholder class	Definition
Software Provider	This can be a single person, a company or an association providing software solutions, tools, components, algorithms (if packaged as a software component).
Hardware Provider	This can be a single person, a company or an association providing hardware solutions, such as smart meters, sensors, VRA machines, irrigation valves, milking robots, ...
Agri Suppliers	This can be a single person, a company or an association providing things like feed, seeds, fertilizers, pesticides, fungicides, ...
IT Services	This can be a single person, a company or an association providing services like software integration, data-, processing- or cloud-services.
Advisory Services	This can be a single person, a company or an association providing advisory and consultancy to farmers in terms of rules and regulations, including training to farmers, quality supervision services, lobbying associations, …
Public Authorities	This can be public authorities such as governments, municipalities etc.
General Public	you and me

We have also defined two roles for each stakeholder. Each stakeholder can later use the DEMETER platform as a *consumer*, or as a *provider*. Under these perspectives we have again analysed the interests of the stakeholders.

As an example, farmers [as *consumer*] indicate that they would like the DEMETER platform to support them in taking decisions to improve efficiency.[1] Farmers also expressed the requirement to be able to compare themselves with neighbours or direct competitors. These requirements are no surprise, since both are part of the main goals of the project and participating pilots would be expected to raise them. However, farmers also expressed the requirement to have access to certain data and information. For example, the requirement for information on legal certainty was expressed very specifically. An aspect not raised in the initial survey is marketing. Once brought to the attention of the Pilots, it became apparent that of course there is also an interest of farmers to be able to promote the fact, that their products have been produced in a more sustainable, environmentally, ecologically or ethical way. But the role of the farmers is not limited to be a consumer, farmers [as *provider*] also offer to make their data and knowledge available on the platform.

Software providers [as *providers*], on the other hand, have an obvious interest in offering software solutions via the DEMETER platform. This allows the DEMETER portfolio to be extended by additional features and interoperability mechanisms. At the same time, software providers [as *consumers*] can also use the platform to obtain information (e.g. practical knowledge from farmers or to determine unmet requirements). Interest in data and in data models developed in DEMETER is also expressed.

[1] This requirement is very prominently named in the DEMETER Enabler Hub survey, which has been carried out jointly by WPs 3 and 4, and is documented in *D3.2 DEMETER Technology Integration Tools - Release 1, D4.1 - Decision Support, Benchmarking and Performance Indicator Monitoring Tools* and *D4.2 - Decision Enablers, Advisory Support Tools and DEMETER Stakeholder Open Collaboration Space*.

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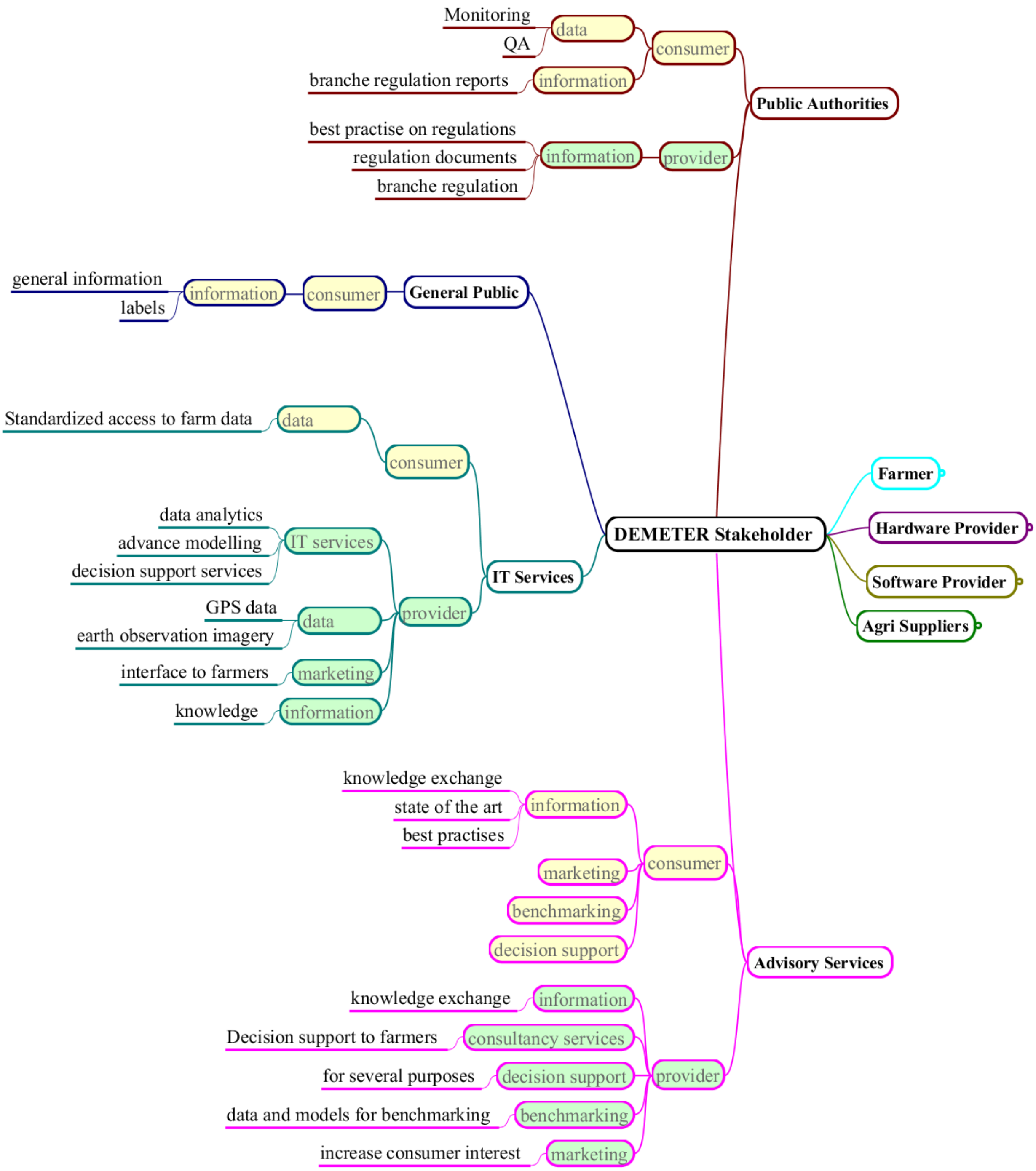
The results of this analysis are shown as mind maps in Figure 3. It summarises the generic stakeholder classes and their general interest in the role as consumer and provider. In the role as a consumer the platform is used to get "something" of interest. In the role as a provider, "something" is made available via the DEMETER platform. The pilots were asked to name "things" that they, as providers, want to make available through the platform and "things" that they as customers of the platform would like to have available. The results show that, besides to the technical developments that are being aimed for in DEMETER, there is a broad interest in information/knowledge, marketing and data.



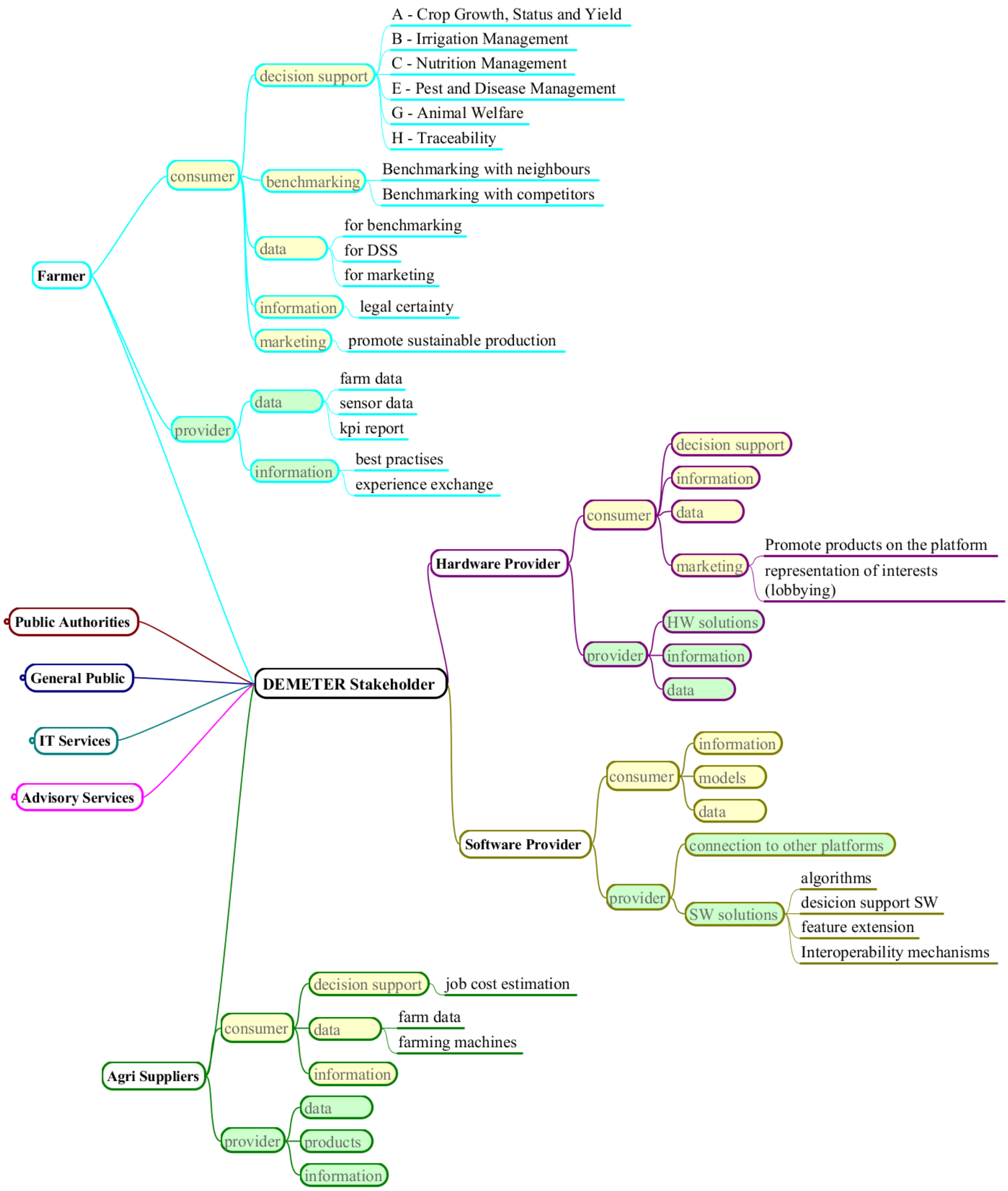


Figure 3: DEMETER Stakeholder Mind Maps

6.5 Next Steps

6.5.1 Clarification of the Stakeholder Analysis

In order to evaluate the generic stakeholder classes, to get a deeper understanding and to identify white spots regarding the stakeholder landscape in DEMETER, an extended stakeholder workshop was initiated in collaboration with WP5, 6 and 7. This workshop (organized and hosted by WP6 and WP7) was successfully conducted on September 4th. The goal of this workshop was to get a vivid image of the different stakeholder groups involved, their business context, needs, but also attitudes, concerns, and other characteristics relevant to the DEMETER project.

The workshop was conducted in a remote co-creation style involving as many DEMETER project consortium partners as possible. Zoom was used to facilitate and host the workshop. To implement a participatory approach, the collaborative online whiteboard application ‘Mural’ was used to collect and organize input provided by participants. Of the 72 registered participants 60 attended the two-hour remote workshop. During the main part three Zoom breakout rooms were set up and facilitated by two members of WPs 5, 6 and 7 each. Participants were split randomly into these groups and assigned to one breakout room to work on one of three parallel sessions.

The workshop consisted of three tasks that were prepared on a collaborative Mural whiteboard. In the first task participants were asked to brainstorm and identify as many stakeholders as possible also keeping in mind the generic stakeholder classes defined in previous work. The findings were arranged, filtered and discussed to clarify, cluster and remove doubles. In the second task participants were asked to classify the stakeholders in the influence-interest matrix which is a key step in the stakeholder analysis and management process. The goal of this task was twofold. On the one hand, the outcome is a visual representation of a stakeholder map which allows to identify key players but also less important stakeholders in regards to the DEMETER Project. This approach reveals information on how particular stakeholders are best managed and gives indications on which stakeholders should be managed more closely compared to others. On the other hand, this task raises awareness on the stakeholder management and engagement process itself in the project consortium.

In preparation of the third task participants conducted a dot voting (a democratic voting process where participants express their favour of an idea by casting votes via little dots) and identified the five most relevant stakeholders. The focus on five key stakeholders allowed a more detailed analysis on their needs, interests and concerns. Comparable to task one, in a mixture of brainstorming, brainwriting, and open discussion every participant was asked to brainstorm needs, interests and concerns for each of the five key stakeholders.

The results were documented together during the workshop by using mural. The mural board of group three, which was filled during the workshop, can be seen as an example in Figure 4 below:

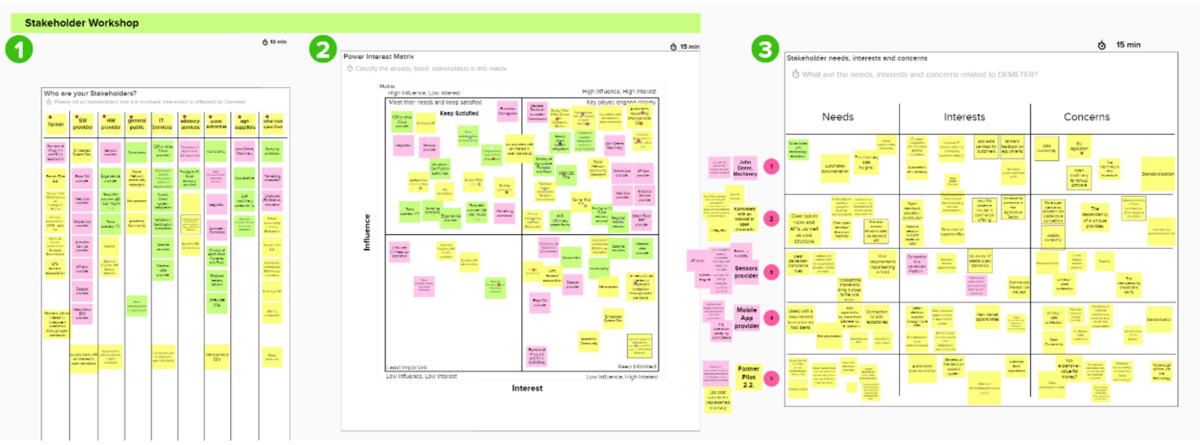


Figure 4: Screenshot of Mural Board (in this case from third working group) representing the three tasks and the results collected during the extended stakeholder workshop.

This workshop is the basis for follow-up activities that WP6 and 7 will plan and implement together. WP6 will prepare a revised communication and dissemination strategy using a more targeted approach to engage stakeholders (update of D6.1). This will also feed into delivering a roadmap for stakeholder involvement. WP7 will further use the results to plan MAA activities, such as quantitative surveys with external stakeholders to evaluate our initial findings. Focus groups with internal and external stakeholders are also planned to address the most important needs and concerns in more detail, and to jointly design and discuss possible DEMETER solutions.

6.5.2 Vision Scenario for DEMETER Digital Spaces

The identified stakeholder interests will be considered in the user-centred development of DEMETER Digital Spaces. In addition, based on these analyses, the following steps can also be envisaged:

- Development of stakeholder specific user scenarios describing the process by which the stakeholder uses the DEMETER Platform and the user's motivations.
- Targeted multi-actor approach activities that might focus on a specific stakeholder groups to disseminate and to discuss the DEMETER Digital Spaces.
- Targeted dissemination activities can be carried out more effectively by addressing the direct needs of stakeholders.

The work will be done in WP7 (Tasks 7.1 and 7.2) in close cooperation with WP5 and 6. The results of the activities will be summarized in the Deliverables D7.3 - MAA Activity and Pilot Report 1 (April 2021), D7.5 - MAA documentation and dissemination material (August 2021) and D7.9 - MAA Activity and Pilot Report 2 (February 2023).

6.5.3 Technical Requirements Management

The technical requirements are jointly maintained by WPs 2, 3 and 4. The status and priority of the requirements will be periodically updated. Each WP manages its own requirements. Cross-WP requirements or requirements originating from other WPs are jointly evaluated. Traceability matrices will link back on how the technical requirements and the pilot/stakeholder needs are satisfied.

Changes to the requirements during the project lifecycle either stem from the above-mentioned sources (the pilots stated needs; platform requirements proposed by partners; relevant technical assets brought in by partners or available as COTS; state-of-the-art and standards analysis) or raised through issue tracking reports. These will be evaluated by the relevant teams before been accepted.

7 The DEMETER Pilot Clusters

The pilots have been grouped into 5 thematic clusters, which are described in this section.

7.1 Pilot Cluster 1 – Arable Crops

Cluster 1 focuses on an efficient water management system, improving the consumption of water, fertilizer and energy in irrigated arable crops.

The automated irrigation management in optimizing water quality and quantity is of great importance for the pilots involved in cluster 1 as it considers the crops' water needs or the differences in different parts of the same field. Early warning systems and advanced visualisations related to measures of nitrogen levels are also very significant.

Cluster 1 is composed by different pilots that provide services for maximising water use efficiency in different irrigation crops, through the deployment of appropriate sensor systems and science-based decision making.

The pilots involve different technologies such as IoT Sensor networks, multispectral and thermal images, automated image processing workflow, machine learning algorithms, weather stations, irrigation system brokers, and advanced Decision Support Systems.

The Cluster 1 pilots will contribute to DEMETER objectives by demonstrating how the farmers and cooperatives benefit from decision support to control their production more efficiently and to manage Farming Information Systems and associated technologies. Also, the pilots will demonstrate the impact of digital innovation and interoperable platforms allowing the farmers to increase the possible combination of tools from different suppliers or providers.

7.2 Pilot Cluster 2 – Arable Crops

Cluster 2 focuses on arable crops and especially on the establishment of precision farming and the usage of agricultural machinery improving the efficiency of data acquisition, data sharing and benchmarking on the productivity. An arable crop farmer is creating manually or automatically a big amount of data. The difficulties lie in the automation of the data integration into a Decision Support System (DSS) and the interpretation of the data.

The cluster 2 pilots use multiple layers (weather, field data, soil data, Ag machine motion, economic situation…) to integrated them in a unified layer accessible on DSS, analyse them and visualize the results to take action, such as production technology and management.
All 4 Pilots in cluster 2 provide services for maximising the farm output from the data collected. To reach this objective, several standards will be used like OGC, W3C, ISOBUS and Ag-Gateway.

Cluster 2 will contribute to DEMETER objectives 2 & 3 by enhancing the interoperability space of the Agri-food domain and empowering the farmer to make the best out of his data.

7.3 Pilot Cluster 3 – Fruits and Vegetables

The efficient use of resources for environmental and economic purpose requires complex decision-making processes. Especially in uncertain situations, e.g. due to climate change, this is playing an increasingly important role. Cluster 3 focuses on supporting farmers in protecting the health and the quality of production of woody and vegetable crops in several European countries. These crops include olive, grape, orange, apple trees and potato.

Three of the four pilots focus on a single crop, while the other pilot focuses on three different fruit tree crops. The aim of the pilots is to spread ICT solutions in supporting farmers in the decision-making process to address the following issues:

1. More efficient use of irrigation water;
2. More efficient use of nutrients for crop fertilization;
3. Monitoring tools to estimate plant phenology, status and productivity over time, using remote sensing technologies;
4. Support integrated pest management by forecasting models, IoT sensors and automatic traps;
5. Provide instruments to help farmers in estimating the potential crop yield before harvesting.

To these purposes, several technologies will be integrated: existing digital farming platforms, IoT sensor networks, models and decision support systems, remotely sensed data, advanced data analysis tools and techniques.

One of the main constraints in adopting ICT in agriculture is related to the fragmentation of the available solutions when assessing the complex needs of the farmers. The scope of this cluster is to cross-fertilize each pilot with the solutions and results of other pilots. One example are automatic fruit fly traps tested in orange groves in pilot 3.3, which can also be used in olive orchards in pilot 3.1. The remote sensing solution developed for potato farming in pilot 3.4 can be adapted to fruit tree crops in the pilots 3.1, 3.2 and 3.3. The Olive Fruit Fly model in pilot 3.1 can be applied with precision farming tools from pilot 3.2 etc. The final scope is to give input to technology providers on how to integrate the solutions to improve their business and to farmers on how to manage their decision making and to get answers at their own requests.

The cluster groups pilots with different Farm Management Information Systems (FMIS), sensors and related technologies, deployed in different farmers and environments. The cluster will perform several interoperability activities within the cluster and the individual pilots, showing to farmers and providers the advantages of the DEMETER approach in supporting a trusted data sharing (objective 1) and creating an interoperability space for knowledge exchange (objective 2). The adoption of the same technologies in different environments and farming approaches will help to develop a benchmarking mechanism (objective 4).

7.4 Pilot Cluster 4 – Livestock

This cluster focuses on supporting farmers for livestock animal health and high quality in the production of animal products with farmers' dashboards that include AI-based prediction and decision support for animal Health and animal products. Three pilots are milk cow oriented with one focusing on AI Machine learning for predictive milk production and dashboard including data flow for invoicing, settlement, accounting, bank and insurance. Two pilots focus on milk quality and animal welfare tracking through health and welfare recording protocols which will be applied using various sensor technologies and digitalised records. The fourth pilot is focusing on chicken health and optimal production.

The main aims of the pilots are to contribute to more effective production and animal welfare:

- More efficient methods for measuring production and animal welfare
- More efficient production with AI-based systems and other decision support for farmers and related business.

To these purposes, several technologies and methods will be used: existing digital platform, IoT sensor networks, models and decision support systems, advanced data analysis tools and techniques.

One of the main constraints is related to the fragmentation of the available solutions when assessing the complex needs of the farmers and the related businesses. This will be addressed in the pilots where different stakeholders and the MMA approach will be used. In the cluster there will also be important to cross-fertilize each pilot with the solutions and results of other pilots.

The cluster 4 addresses all the six DEMETER objectives through its full dashboard approach and the objective to support increased animal welfare and efficient production approaches across multiple pilots.

7.5 Pilot Cluster 5 – Full Supply Chain, Interoperability, Robotics

While other clusters are focusing on activities and operations taking place on farms, the goal of Cluster 5 is to address pre and post farm activities, i.e. to address the complete food supply chain.

There are 4 pilots in the cluster focusing on four different areas: fruits & vineyards, apiculture, cattle, and poultry. Both supply and demand sides of the supply chain in addition to the on-farm management activities are addressed, thus contributing to creation of a more transparent supply chain increasingly demanded by consumers as well as legislators.

Cluster 5 pilots will enable validation of interoperability of platforms and solutions used in different sectors as well as validation of interoperability of platforms used for management of on-farm and post-farm (supply chain) activities. The use of distributed ledgers in combination with data exchange protocols designed for the supply chain domain and item level unique identities will be validated in combination with on-farm management solutions.

The complete lifecycle of a product will be covered by inclusion of representatives of the retail, transportation and recycling industries through an open call. This will allow us to expand the project's impact and better understand challenges and implications of providing traceable information about the food production throughout the value chain. We will also be in position to engage consumers who are one of the very important stakeholder groups increasingly interested to know what they eat, how the food was produced and what impact that production has on natural resources.

8 The DEMETER Pilots

To obtain a common understanding of the scope and objectives of the DEMETER pilots, the pilot leaders have been asked to provide a description by addressing the following common questions:

- What is the pilot about?
- How does the current scenario look like?
- How can a future scenario look like?
- How do you want to achieve this?
- What are the benefits for the pilot?
- Who are the key stakeholders?
- What are the main roles and interests of the stakeholders?

The initial version of this report provided the base for all other WPs. A major change in this version is that the initially named stakeholders have been translated from what were largely named companies, persons and specific interest to generic stakeholders, roles and their relationship to generic "building blocks". The approach is described in detail in chapter 8 of this report. For the sake of clarity, a shortened comprehensive summary table of the stakeholders and their interest in DEMETER Decision Support Areas is provided in each pilot chapter. The Decision Support Areas have been defined in WP4 in collaboration with the pilots and are described in detail in the WP4 reports.

A more detailed version of the stakeholder requirements analysis and the mapping to required building blocks and DEMETER Decision Support components is provided in Annex 8. The information in that table will be further refined in *D5.3 Testbed, deployment, system extensions and applications for pilot round 1*, which will become available August 2020. Eventually the table will provide a clear mapping of stakeholders, their requirements and where these are addressed in DEMETER. This will not only help to narrow down Open Call topics, but also synergy potential between and across pilots and WPs.

The following sections present the results for each pilot. Some explanatory text is intentionally repeated in each pilot description. The idea behind this is to provide self-contained chapters, so that the reader can directly pick his area of interest without missing any relevant context.

8.1 Pilot 1.1 & 1.2 - Water and Energy Savings in Irrigated Crops

Pilots 1.1&1.2 aim to increase the production of irrigated crops, whilst saving water and energy. The main objective is to optimise irrigation by improving the automation of the irrigation zones. This includes using interoperable remote-control systems and robust management systems adapted to the each required condition. The of use real time monitoring and control of water supply in combination with energy efficiency improvements is based on informed decisions from farm to fork. This will balance water and energy consumption and result in great water and energy savings.

The Pilot will be deployed in two sites in Spain:

- Irrigation Community "Left side of Porma River" in the Castilla & León Region, where Tragsa is working in the deployment. It comprises 11 irrigation sectors, of which 8 are modernized with pressurized networks. In total, 1.302 hydrants serve 12.500 ha of arable land.
- Irrigation Community "Comunidad de Regantes Campo de Cartagena" in the Región de Murcia, where OdinS, in close collaboration with the Universidad de Murcia, is working in the deployment based on a web-based platform called *Smart Agriculture*. In total, 980 hydrants serve 41.920 ha of arable land (lettuce, melon, artichoke, broccoli and tomato, citrus fruits, etc.)

where the irrigation period covers the whole *hydrological year*. Distribution of water uses quotas based exclusively on plots size and the amount of available water on a system of orders and shifts that follows a restricted number of directives.

Figure 5: Location of Pilots 1.1 and 1.2

8.1.1 Current Scenario

Most of the national modernized irrigation systems already have remote control capacities and irrigation management systems, aimed at more widespread improved water management. But these remote-control systems are closed solutions that do not share software or hardware elements, which limit their possibilities of modification or extension. In addition, these systems are subject to strong wear and tear with about ten years of useful life. Due to these limitations, only gradual renewal of the systems is possible. Often only identical equipment can be used, which has increasingly negative economic repercussions, e.g. when the original supplier no longer exists.

Another important issue is that the existing irrigation systems have not been designed to be interoperable. Since the information the components exchange was not meant to be used by applications other than their own, standardisation of data or interfaces was never considered. Without interoperability, irrigation components that are dependent (such as pumping stations, irrigation branches and hydrants) cannot exchange useful information to optimize exploitation.

All this has an impact on irrigation facilities that are not very efficient in terms of saving water and energy efficiency.

8.1.2 Envisioned Scenario

The irrigation control systems are developed by specific manufacturers, who are reluctant to allow external users or other third parties to modify their configuration or operation mode. Nevertheless, these systems' devices can expose open and standard interfaces (APIs). This fact will allow irrigation communities to expand their systems with different vendors' devices, having a heterogeneous environment but with the capability of interoperating with all the devices responsible for the irrigation.

8.1.3 Approach

The use of open and standards-based technologies provides a significant advantage regarding how systems can interact and interoperate. For this reason, it can be a great improvement to have a Standard Model of Water Management irrigation in order to provide a common interface (API) and information model shared between the water management and the control systems.

Currently there is no consolidated standard, but Tragsa is working with ISO to develop the new standard ISO 21622 and it is already stable.

Also, OdinS is working in its web-based platform *Smart Agriculture* with IoT devices that comply with standard and open protocols (i.e. MQTT or CoAP) and that can offer interoperability with other systems also complying with standards (i.e. NGSI and NGSI-LD).

8.1.4 Pilot Software Components

This pilot is being deploying based on two main software components:

8.1.4.1 Mega Coordinator

The mega coordinator manages the different connections between all the management irrigation systems and all irrigation control systems that support ISO 21622. It is formed by different web services (i.e. SOAP and REST) which correspond to the operations defined in the standard and a web interface where security and the possible connections can be managed.

From the interface we can configure the different control elements, such as remote station, concentrator station or master station, which can be managed:

Figure 6. Subsystem Register

From the interface we can also configure the different management elements that can manage the subsystems and what kind of operation, such as CreateRecipe (which allows the creation different irrigation plans) or Read (which allows reading the value of different properties), can be executed:

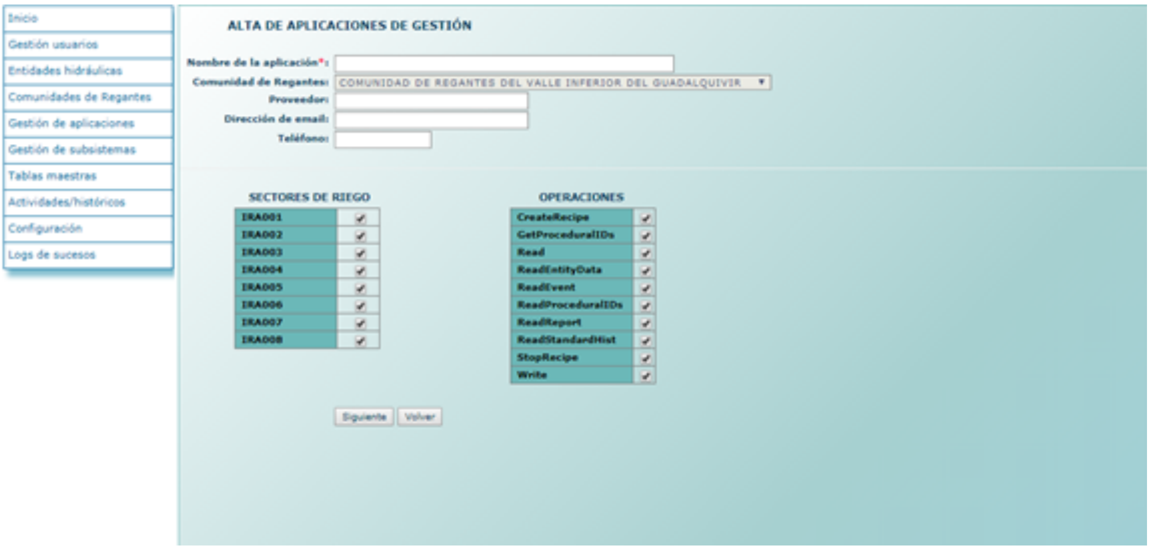


Figure 7: User Register

Permissions can be managed individually by item and operation as shown in the next image:

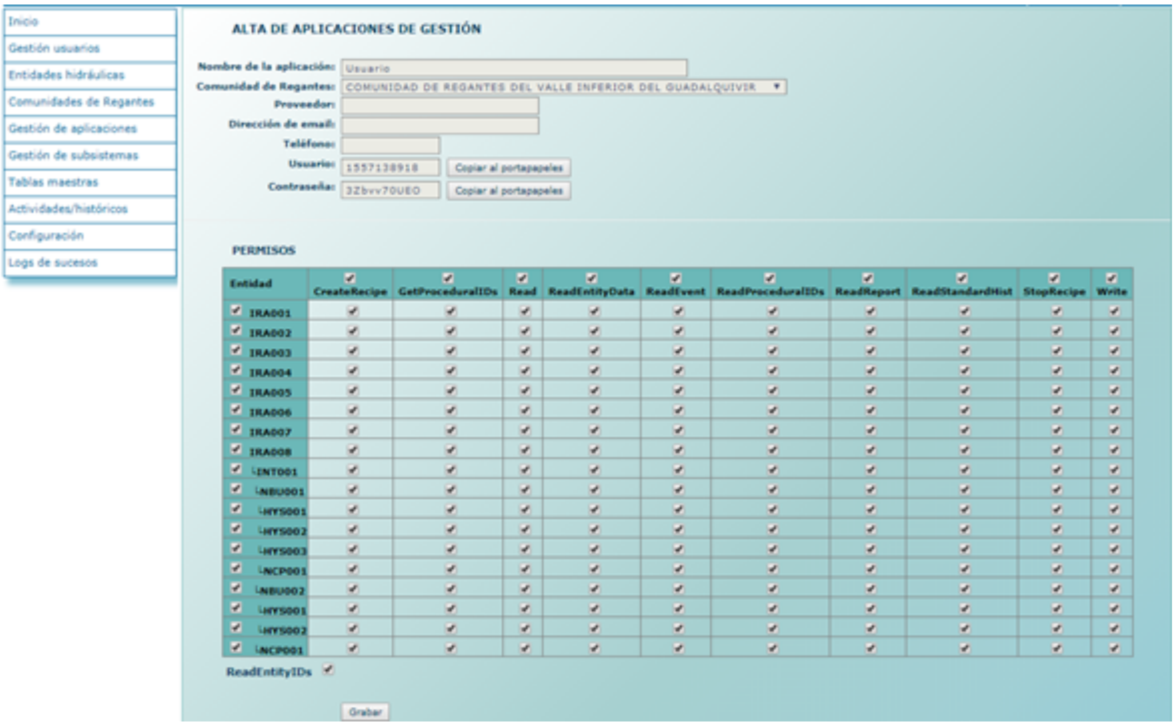


Figure 8: Permissions

8.1.4.2 *Smart Agriculture*

Smart Agriculture is a web-based platform based on standards and open protocols (i.e. NGSI, MQTT, CoAP). It comprises specific modules for the integration of IoT devices, basic data exploitation and map-based interface.

The adoption of standards and open protocols makes it easy to integrate IoT devices which are standard compliant. Additionally, exchanging information in both directions (from and towards) with third-party platforms is also possible, thanks to a north-bound interface (API based on NGSI and NGSI-LD).

This platform allows for customized rules for triggering alarms and actuations depending on the measurements provided by sensors or weather stations. Also, reports, integration of agronomic operations, parcels information or personalized graph charts are also provided thanks to a nice web-based interface:

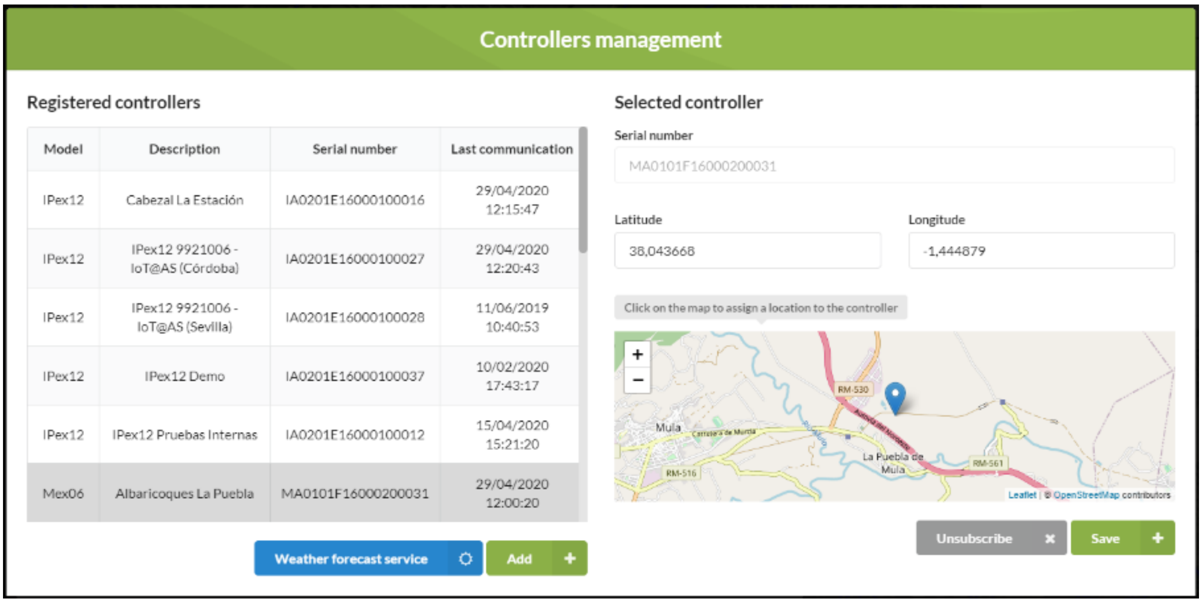


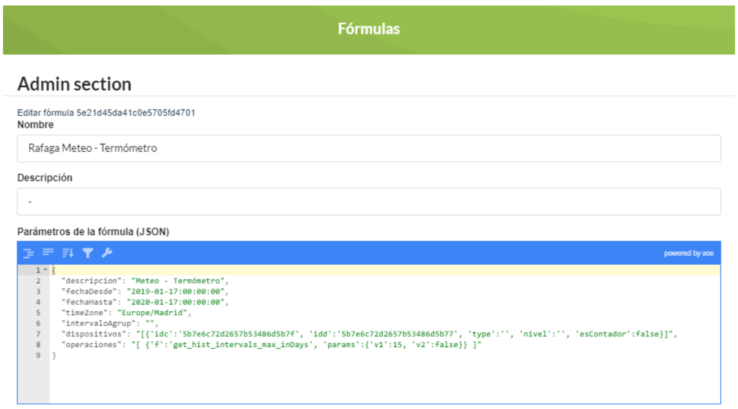
Figure 9: Controllers can be edited and geo-positioned

Agronomic operations: Weather

- Solar radiation
- Thermometer:
  - Min/Max/Average temperature.
  - Degree day.
  - Accumulated degree day.
  - Thermal integral.
  - Daily cold hours.
  - Accumulated daily cold hours.
- Min/Max daily wind speed.
- Rainfall periods.
- Weathervane directions.

Agronomic operations: Counters

- Consumption.
- Min./Max. daily irrigation.
- Shortest daily irrigation period.
- Longest daily irrigation period.



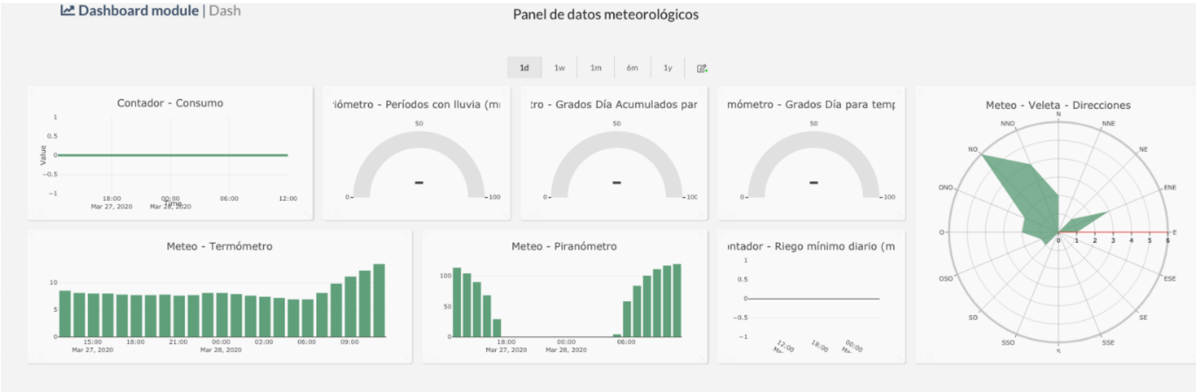


Figure 10: Agronomic operations can be edited and represented in a dashboard as graph charts for reports

The Geographic Information System for Agricultural Parcels (SigPac) is a system offered by the Government of Spain that allows users to identify geographically the parcels declared by farmers related to area cultivated or used by livestock. This platform also offers Web Map Services (WMS) and Web Feature Services (WFS), both based on OGC (Open Geospatial Consortium) standards, to access information.

GIS integration is accomplished using OGC WMS and WFS specifications, so that SigPac information regarding crops can be obtained. Such integration makes also possible to integrate other geo-localized information such as IoT devices, satellite images, or even drone images.

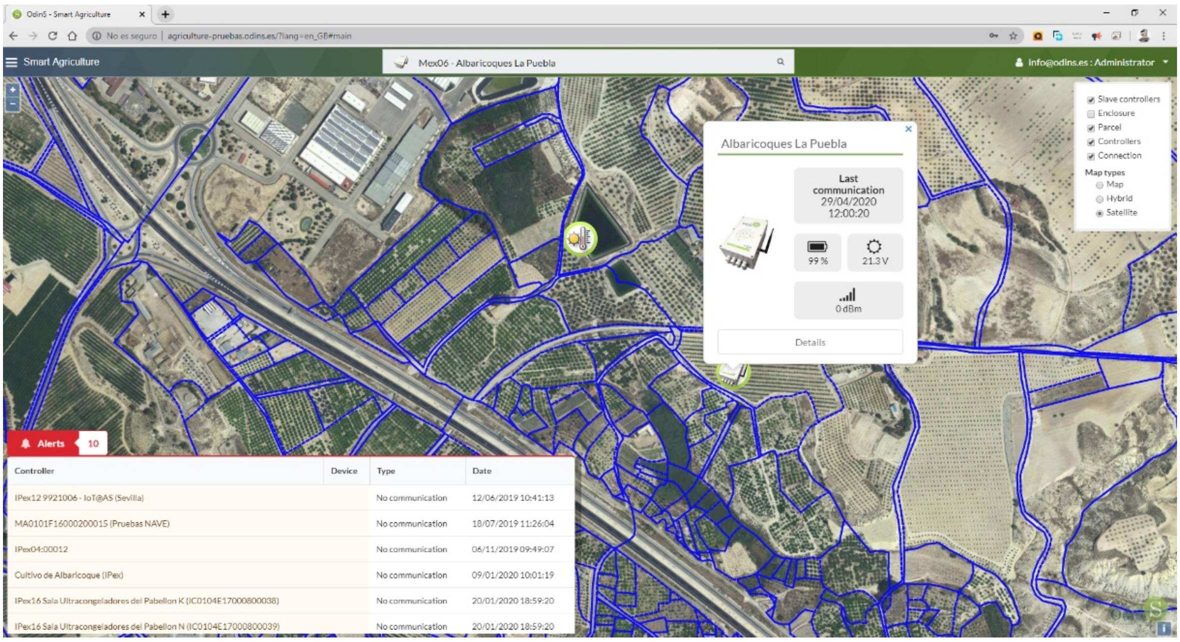


Figure 11: Geo-localized parcels and IoT devices can be easily located and accessed

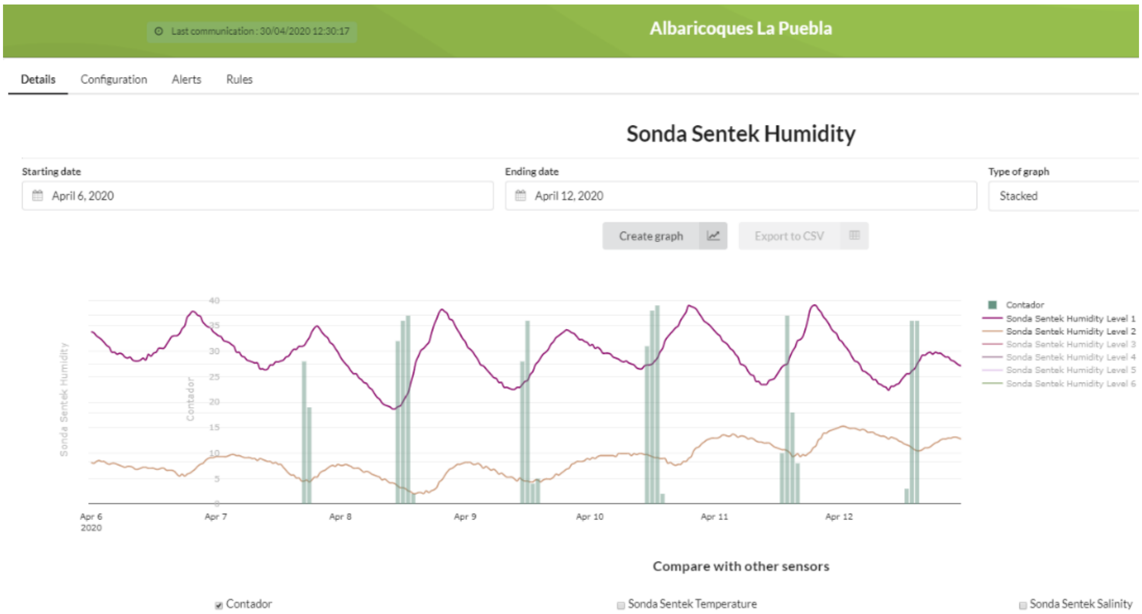


Figure 12: IoT devices for configuration or historical graph charts representation

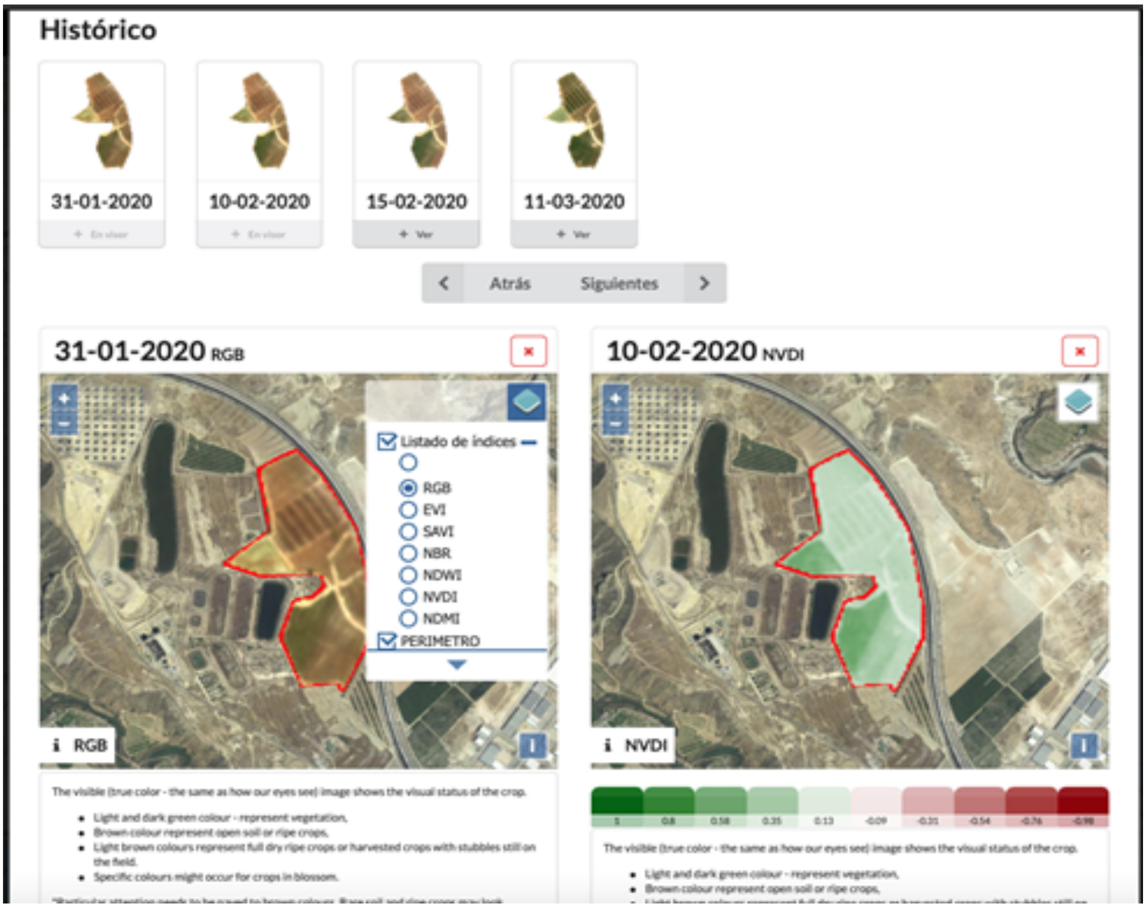


Figure 13: Satellite historical parcels crop imagery representation

8.1.5 Expected Benefits

The implementation of standards-based and interoperable elements will facilitate the exploitation and maintenance of irrigation systems achieving greater efficiencies in the water and energy savings.

The communities of irrigators who for any reason need to make a change in any of the components of their system can now make it more easily, since any system that meets the standards can be integrated without major changes.

Even irrigation communities that do not have a management irrigation system yet can safely follow this approach. The risk is lowest, because independence from a single company's proprietary solution is the best long-term investment protection.

8.1.6 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p).

The following table provides an overview of the identified stakeholders and interests for pilot 1.1/1.2:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
smart water meter	c		p				
smart electricity meter	c		p				
interoperable interfaces	c	p	p				
soil parameter sensors	c	c	p				
weather forecast service	c	c					
model for efficient use of resources	c	c/p					
irrigation requirements model	c	c/p					
kpi data export	p	c		c	c		
benchmarking report	c	c/p			c/p		
marketing label / tracing	p	p	p				c
marketplace	c/p	c/p	c/p	p			c
knowledge base	c/p	c/p	c/p	p			c

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.2 Pilot 1.2 - Smart Energy Management in Irrigated & Arable Crops

The descriptions of the Pilots 1.1 and 1.2 have been merged in this document, since they involve the same stakeholder classes and requirements.

8.3 Pilot 1.3 - Smart Irrigation Service in Rice & Maize Cultivation

Pilot 1.3 aims to improve the management and automation of rice irrigation, along with nitrogen zonal fertilisation. Maize is also an important crop for rice growers, as it is included in the majority of crop rotation systems—at least once every three years. Therefore, the present pilot will also improve the management of both water and fertilisation in maize crop.

The region of Central Macedonia is the main rice producing area in Greece covering more than 20.000 ha. According to the Local Irrigation Authorities (TOEV), every 1 ha of rice field consumes 11,200 m^3 of irrigated water, delivered mostly from river Axios through a very efficient network of irrigation and drainage cement-made channels of several levels. Besides, rice farmers crop-rotate mainly with maize and with alfa-alfa. Crop rotation systems are part of the Good Agricultural Practices, since they offer the only way to efficiently control weeds, diseases and pets. Furthermore, rice has been listed by the Hellenic Ministry of Agriculture as a high-input cultivation, especially in terms of irrigated water needs. On the other hand, maize (mostly cultivated for silage in the area) also has substantial needs for irrigated water during the cultivation season. As such, the automated irrigation management in order to optimise water quality control (e.g. salinity levels) and quantity is of great importance for the pilot area.

The Pilot will be deployed in one main site in Greece and in several locations around Central Macedonia regions:

- ELGO Experimental station of approximately 50 ha at Kalochori area (40°37'4.41"N, 22°49'54.19"E), Thessaloniki, Greece. This will be dedicated to both rice and maize crops, where the smart irrigation system will be deployed, tested and validated.
- At least 10 farmers in the same area of Kalochori and another 10 farmers in other areas will be involved, in order to cover a variable rice and maize environment. These farmers will dedicate fields suitable for testing according to ELGO’s and ICCS’s plan.

8.3.1 Current Scenario

Rice has been listed by the Hellenic Ministry of Agriculture as a high-input cultivation, especially in terms of irrigated water needs. On the other hand, maize also has substantial needs for irrigated water during the cultivation season. The region of Central Macedonia has a sophisticated irrigation network, which is managed by the Local Irrigation Authorities (TOEV). During the summer growing season, the water is distributed gradually to the different regions of the plain and rotated throughout the season. Currently, farmers manage water only by experience, which leads to poor water use efficiency most of the times, as they pre-emptively re-flood the rice paddies to avoid increased salinity, without measuring the latter though. Similarly, maize irrigation is also based solely on farmers’ experience, without considering the actual crops’ water needs or the differences in different parts of the same field. Fertilisation is also managed mostly by experience and frequently excessive amounts of nitrogen are applied to increase yield. Recently, several farmers (or group of farmers) have acquired variable rate application (VRA) machinery. However, they use them only to avoid double spraying (i.e., applying fertilizer on the same region twice as the tractor moves in consecutive parallel lines, in opposite but partially overlapping paths), but not for zonal management based on the real needs of each patch within the field that would fully exploit the potential of such machinery.

8.3.2 Envisioned Scenario

Pilot 1.3 will provide a service for maximising water use efficiency in rice and maize, through the deployment of appropriate sensor systems and science-based decision making. Thus, both water quality (e.g., salinity levels) and quantity will be optimised. Since irrigation is tightly linked to fertilisation, a nitrogen fertilisation advisory service will be setup, leading to optimisation of the spatial distribution of nitrogen application based on the real needs of the field.

8.3.3 Approach

With respect to rice, the automatic Smart Irrigation Service (SIS) will be introduced only in the main pilot area of ELGO. The real-time salinity sensor, which was developed within the framework of SmartPaddy FP7 project, will be slightly improved by adapting the communication system to use a GSM modem instead of Wi-Fi and by adding a height sensor. The SIS sensor will automatically control electric water input valves for irrigation and water outputs valves for drainage. In addition to the automated workflow, the end-users will be able to directly control the sensor by sending messages to overtake actions over the robotic management. In the case of individual farmers with no automatic Smart Irrigation System, the service will provide only information/notifications. In addition, TRAGSA that will engage their irrigation broker and ensure fine-tuning among this pilot and the other 2 pilots of cluster 1 focusing on irrigation. Moreover, the DEMETER system will deploy a methodology for nitrogen fertilisation management using variable rate application (VRA) technologies, based on spatial information collected by the pilot paddy fields through UAVs. More specifically:

- With respect to maize, multispectral and thermal images will be collected at predefined points within the cultivation period using UAVs already owned by ELGO and ICCS.
- Water- or nitrogen-stressed fields will be identified through an automated image processing workflow, as well as through image analysis using innovative techniques, such as machine learning on embedded multicore GPU device for fast decision support.
- Data analytics, decision support mechanisms for optimal resource management/allocation (e.g., water use optimization, optimal scheduling of snapshot propagation).
- Image processing using machine learning algorithms for plant data linked to the plant's irrigation needs/health.
- Support for resource consumption reduction/minimization (e.g., reduction of power consumption on the embedded devices/UAVs to extend battery life).
- Usage of machine learning techniques (e.g., suitable neural networks) in order to forecast optimal irrigation schemes based on data collected on the field for sufficiently large time period.
- Usage of decision support tools (e.g., to support the irrigation-related decisions of producers).

The above exploit modules to be implemented by WP2/3/4 and require some pilot specific SW/HW to be developed as well. The results will be communicated to the farmers through the platform to optimise their irrigation and nitrogen fertilisation practices.

8.3.4 Expected Benefits

The implementation of the Smart Irrigation Service in rice and maize will achieve increase or standardisation of the crop production and greater efficiencies in the water and nitrogen fertilisation savings, decreasing the carbon and the whole environmental footprint of both crops. The adoption of the Smart Irrigation Service by the farmers will create value and positively impact the primary sector of agriculture directly. The pilot will combine a number of different technologies to provide a DSS for the holistic management of irrigation water in rice-maize crop rotation systems. The service will provide a low maintenance, robust and scalable monitoring system at the farm level and on a per-field basis. Overall, the holistic Smart Irrigation Service can be deployed in other rice producing countries.

8.3.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p).

The following table provides an overview of the identified stakeholders and interests for pilot 1.3:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
smart water meter	c		p				
smart electricity meter	c		p				
interoperable interfaces	c	p	p				
soil parameter sensors	c	c	p				
weather forecast service	c	c				p	
irrigation requirements model	c	c/p			p		
model for efficient use of resources	c	c/p			c/p		
IoT monitoring system	c	p	p			c/p	
EO Imagery Analysis	c				c/p	p	
VRA machinery	c		p		p	p	
EO Imagery Analysis	c				c/p	p	
model for efficient use of resources	c	c/p			c/p		
fertilisation model	c				p		
kpi data export	p	c		c	c		
benchmarking report	c	c/p			c/p		
marketing label / tracing	p	p	p				c
marketplace	c/p	c/p	c/p	p			c
knowledge base	c/p	c/p	c/p	p			c

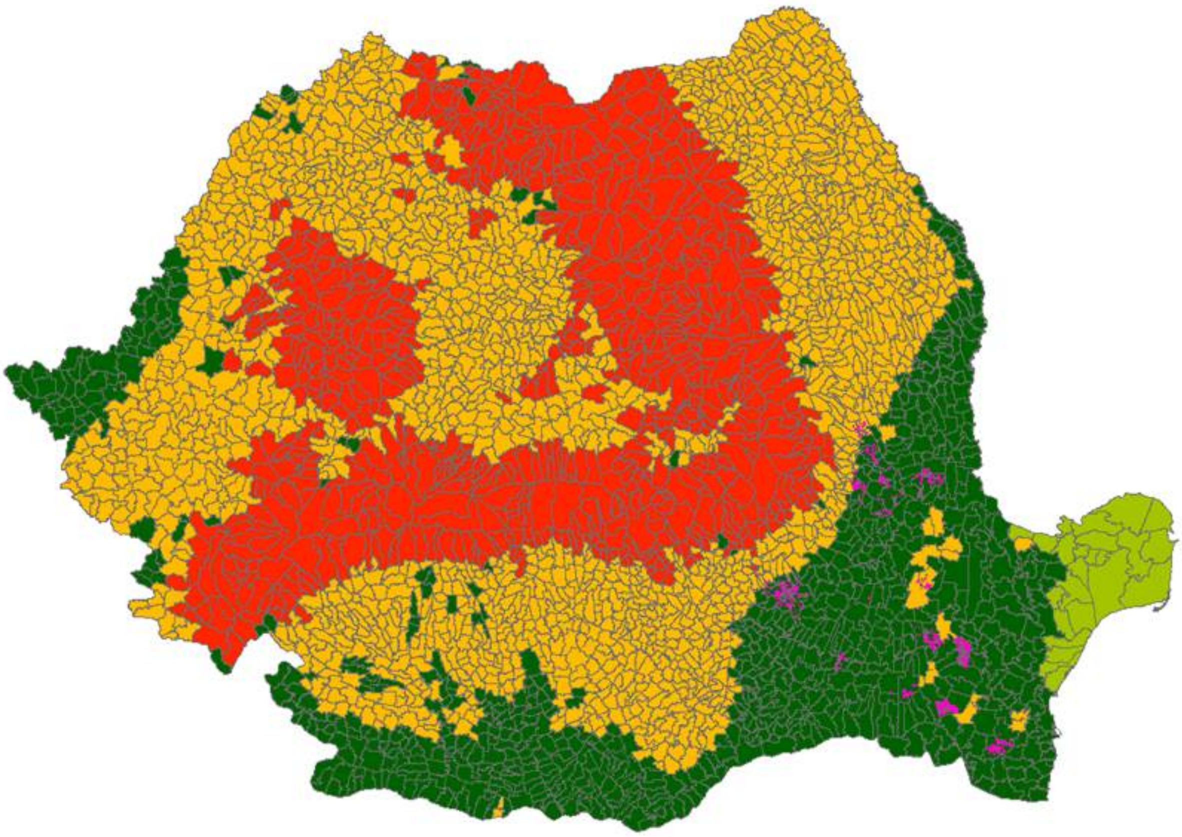
The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.4 Pilot 1.4 - IoT Corn Management & Decision Support Platform

Pilot 1.4 is designed in partnership with the Romanian Maize Growers Association (Asociatia Producatorilor de Porumb din Romania, APPR), our agricultural specialist partner. The pilot will be implemented in locations operated by 15 agricultural farms specialized in field crops, members of APPR, covering roughly 40K hectares.

The geographical coverage will include farms located in the south of Romania that are facing natural or other specific constraints. Due to the different characteristics of chosen regions from the point of view of soil and weather, we are expecting significant variations of collected data that will allow us to better validate the concept. The maps below show the spatial distribution of the pilot parcels (magenta), and the administrative zones (NUTS 5 or LAU2) categorized in colours, based on Less-Favoured Areas (LFA) criteria.

The pilot farmers' parcels are distributed in the dark green areas, which represent Areas facing natural or other specific constraints:



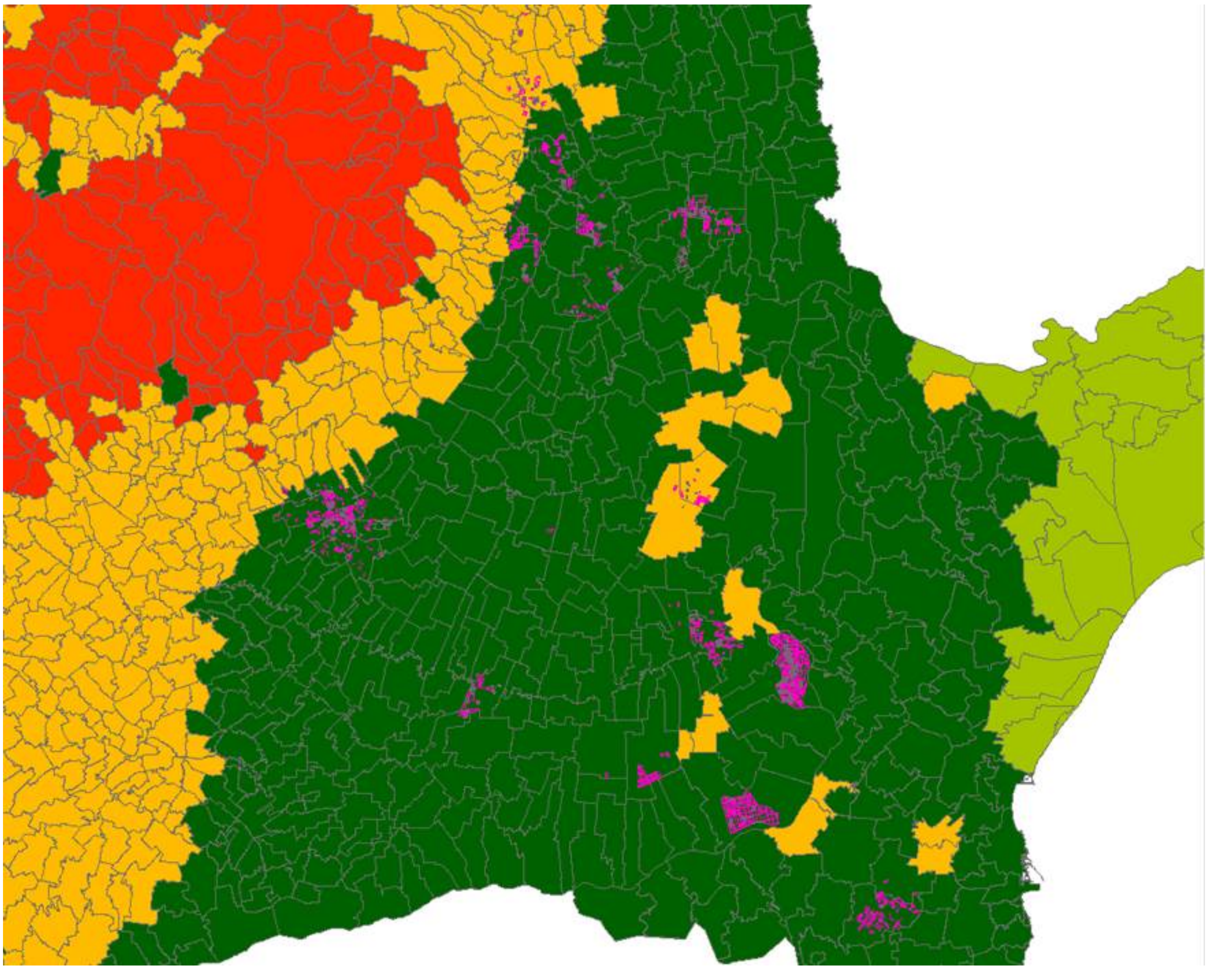


Figure 14:Location of Pilot 1.4 testing parcels

The Decision Support System Pilot for Corn Management within the DEMETER project proposes to bring modern crop monitoring tools for agricultural Corn crops, using combined data from local intelligent sensors, Global Navigation Satellite System (GNSS) receivers, GIS tools, Satellite and UAV imagery.

The main objective of the pilot is to help the farmers to rationalize production costs through decision support maps and management systems, providing information like crop uniformity, excess water presence, and pest impact degree resulted from extreme meteorological phenomena.

8.4.1 Current Scenario

Nowadays, all 15 farms use weather-related data to manage their specific works internally. Some of them use weather stations and basic decision support functionalities on mobile applications. One of the farms uses mobile weather sensors installed on tractors that trigger real-time warnings for the tractor driver, without being connected to a centralized system. Another subset of farms uses soil moisture sensors.

8.4.2 Envisioned Scenario

All farmers are using weather data but only some of the farmers are using sensors to correlate aerial measurements (temperature, air humidity) with real-time and historical data about soil temperature and moisture, crop types and rotations, type of corn hybrids, wind power and direction). Our decision support system should be able to smartly represent this correlated information, offer smart visualizations and trigger real-time or early warning alerts. To achieve this, the pilot will:

- collect heterogeneous data from various data sources (sensors, stations, web sites, external imported excel or image files) and various farms
- create farm groups and profiles corresponding to geographical position, and crop types
- offer correlated data to farmers
- improve responsiveness of Inovagria platform by triggering real-time or early warning alerts
- offer simple and intuitive visualizations
- display data at different levels: farm, group of farms, plot of land, several plots
- display the exact or recommended time to execute an agricultural treatment as irrigation, fertilization, bug or weed removal

8.4.3 Approach

During the pilot implementation we will carry out the inventory of technical existing assets in the farms (weather stations, sensors, communication facilities, coverage).

An IoT / data source mapping on farms should be conducted to validate the practicality of their current technical inventory. An as-is process diagram will be designed, and a fit-gap analysis will be performed. Consequently, we will choose the participating HW components and we will purchase the missing equipment. Some producers or vendors of IoT devices will be contacted for technical descriptions and offers. The pilot will assign to each farm a specific number and type of relevant sensors / data sources. All IoT components and other sources will be technically enabled to feed the Inovagria platform database instance. All farm profiles, type of crops, rotation schemes, calendars, and statistical/historical data will be loaded in the same instance. The current Inovagria platform will be adjusted to accommodate new capabilities/extensions.

Collect real-time data from IoT devices (sensors and weather stations) and from other data sources (imagery, geo-location, GIS, drone footage, statistical data). Improve and extend the existing Decision Support System (DSS) for live support of agricultural processes.

The software application will include 4 segments:

I) Input distribution plans;
II) Warnings of diseases / pests and recommendations for carrying out agricultural works;
III) Combating floods and hydric stress based on 3D models;
IV) Management: Documents, reports, estimates, technological sheets, production estimates, expenses, data centralization.

The application segments are described in detail in the following sub sections:

I) Input distribution plans

The principle for realizing the distribution plans of the agricultural inputs is based on capturing the aerial images of the interest area and processing them with the pixel classification method. The classification method is based on the grouping of pixels with close values, represented by a single colour. An image will be divided into 2, 3, 4 or 5 classes at most depending on the case. E.g.: Case study* - Variable rate fertilization (VRS).

In this case the farmer wants to determine the areas with low potential and apply a larger amount of fertilizer in those areas. Following the processing of aerial images and the classification of pixels, 5 classes are identified, resulting from the application of the NDVI index formula.

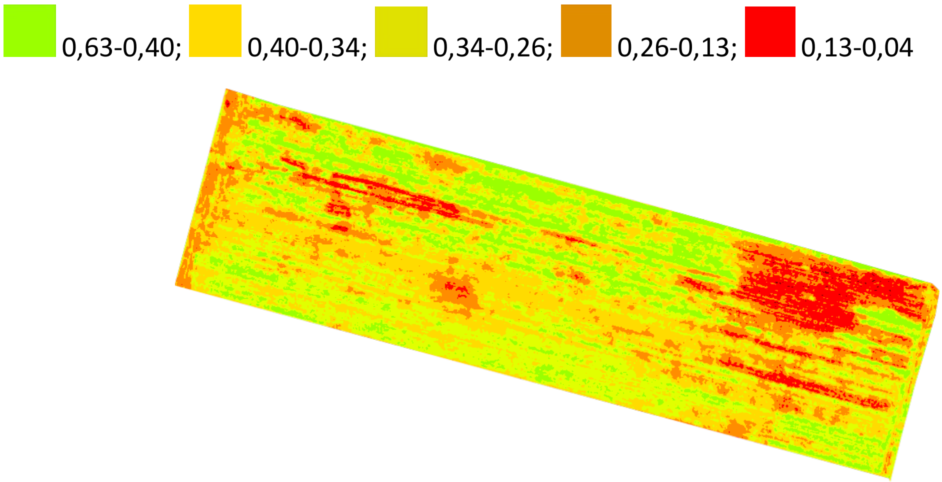


Figure 15: NDVI Example

NDVI (normalized difference vegetation index) is a "unit of measurement" of vegetation development and density and is associated with biophysical parameters such as: biomass, foliar index and percentage of land covered by vegetation. NDVI itself thus varies between -1.0 and +1.0

Following the application of the correlation algorithm, the conditions for distributing the fertilizers corresponding to each area are obtained. The areas represented in red and orange are the most affected and replanting the crop on those areas may be considered.

Obtained orthophoto imagery is transformed into vector features, compatible with the GPS system of the agricultural machines. Thus, the guidelines will be followed on the plot, based on the geographical coordinates. The method will be validated with ground readings (N-Tester measurements), in order to calibrate the legend. Based on this principle the following can be determined: Weed areas, areas with hydric stress, areas affected by pests / diseases or extreme weather events.

II) Warnings of diseases / pests and recommendations for carrying out agricultural works

This section is intended for scheduling fieldwork based on agrometeorological diagnoses and forecasts. Phytosanitary treatments must be administered at the optimal time, so that alert messages can be sent on the farmer's mobile phone, depending on the climatic conditions.

The determination of the optimal moment is based on ground-mounted sensors that will provide information such as: Air Temperature, Air Pressure, Humidity, Wind Speed, Soil Temperature and Moisture and Precipitation (Example: Determination of maize germination). Fact: 10 consecutive days in which positive values are recorded and 100 ° C accumulates (degrees Celsius).

Pest warning will also be based on ground-mounted sensors and mathematical computational algorithms (Example: Warning of occurrence of Tanymecus dilaticollis). At a soil temperature of 4 ° C, the insects leave the wintering places, moving to the surface layer where they wait until the temperature reaches 9 ° C. Once reached, they come to the surface, where they feed on various spontaneous plants, especially thistle. Adults are very active, actively feeding when the average daytime temperature exceeds 20 ° C.

III) Fighting floods and hydric stress based on 3D models

In the case of extreme weather phenomena such as excessive rainfall, water will accumulate in crops, which harms the optimal development of plants. Thus, to prevent puddles, it is recommended to build drains to remove excess water from inside the plot and to be directed to the edge or to build gutters. All these are part of future land improvement works and can be done based on digital terrain models.

3D models can be made with the help of drones when the flight is made at 2 different altitudes or 2 positions of the camera. Only orthophoto images can be used to ensure crops and damage assessment. Hydric stress in agricultural crops (lack of sufficient water in the soil) can lead to enormous damage, so irrigation recommendations (position and quantity) can be made based on aerial images and ground-mounted sensors.

Depending on the cases that will appear in the next 3 years in the 15 agricultural farms where we will install the sensors, this chapter will be completed with real examples.

IV) Management

The software application will also have a section designed to generate reports, centralizations and estimates in accordance with the accounting sector. This includes detailed estimates of expenses for the next year and production evaluations. Also, in this section there will be a column for inserting phenological data from the field for the result of the technological file.

8.4.4 Expected Benefits

Improve the existing decision support system of Inovagria management platform by extending the number of correlated data types which will trigger a more educated automatic decision and will provide:

- More information to farmers (correlated data: weather, soil properties and hybrid maturities, geo-location, etc.) will facilitate faster and more accurate decisions.
- Real-time warnings and forecasts.
- Increase awareness of the importance of Decision Support Systems.
- Water use, fertilizer rate and pesticide optimization.
- Crop works decision time improvement.
- Agricultural system durability stability.
- Profit growth gain through larger and higher quality productions.
- Maintenance of the sustainability for farming systems.

8.4.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p).

The following table provides an overview of the identified stakeholders and interests for pilot 1.4:

Interests	Stakeholders						
	Farmer	SW provider	HW provider	Public	Advisory	IT Services	General
recommendations for water/fertilizer management	c	p					
early warning system	c	p					
data export	c	p					
soil parameter sensors	c	p	p				
weather forecast service	c	p		p		p	
weather station / integration	c	p	p				
real-time data	p	c					
web processing services / EO Imagery		c				p	
generic data gateway	c/p	c/p	p			p	
academic research	c/p	c	c		c/p		
real-time data	p	p	p	p	c/p		
generic data gateway	c/p	c/p	c/p	c/p	c/p	c/p	
kpi data export	p	c	p	c	c		
benchmarking report	c	c/p			c/p		
marketing label / tracing	p	p	p				c
marketplace	c/p	c/p	c/p	p	p		c
knowledge base	c/p	c/p	c/p	p	c/p		c

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.5 Pilot 2.1 - In-Service Condition Monitoring of Agricultural Machinery

This pilot aims at demonstrating the potential application of onboard sensors for in-service monitoring, as well as testing the legal applicability of existing after treatment (AT) sensors as alternative to Portable Emission Measurement Systems (PEMS) while considering aspects of data management, privacy and integrity.

The Pilot will be deployed in two sites in Germany:

- 2 farms (250 ha), one site per farm; machine monitoring is independent of land coverage; however farming task and machine load could be an influencing factor.

8.5.1 Current Scenario

With European Stage V non-road emission standards, gaseous pollutant emissions must be monitored and documented from 2019 onwards for new combustion engines in use. This must be handled with the usage of portable emission measurement systems (PEMS). These systems need to be attached to a number of nine selected machines in order to analyse the emissions of the vehicles during regular operations. Engine manufacturers are responsible for the execution and must report to legal institutions. This solution is challenging since expensive equipment as well as trained personnel are required. PEMS are obligatory and there are no other appropriate methods which fulfil technical nor legislative requirements yet.

Figure 16: John Deere 6250R with portable emission measurement system
Source: Technologie- und Förderzentrum TFZ

8.5.2 Envisioned Scenario

Using onboard sensors for in-service monitoring of engine data as well as data of the exhaust gas after treatment decreases the need of PEMS. Storing and analysing selected data as well as providing defined information to legal institutions helps to monitor that machines follow the regulations and offers the possibility to use the collected data for further improvements (e.g. optimizing machine and simplify maintenance).

8.5.3 Approach

Using for example NOx-conversion, exhaust temperatures, and further not-yet-fully-explored additional or alternative data from the CAN-Bus, algorithmically ensuring high quality of continuous data streams, and analysing the data in real-time by making use of the most appropriate algorithms and technologies, will allow monitoring, documentation, and using the analysis results for further actions. The approach will be evaluated by monitoring real driving emissions and diesel engine conditions.

In general, we plan to develop the data quality assessment component in pilot 2.1 as illustrated below:

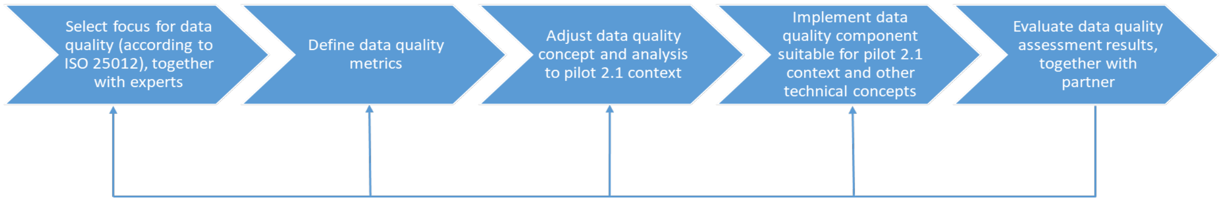


Figure 17: Data quality assessment component in pilot 2.1

We will focus on the quality of machine data (sensor data). This led us to define, what a sensor and what sensor data are.

There are multiple definitions about what is a sensor. However, we can take as a basis the description proposed by (Sensor - Wikipedia 2020): “In the broadest definition, a sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor.”

In the context of DEMETER (i.e., WP2 and the pilots on which we focus our work), we primarily talk about physical sensors. These sensors measure changes in a physical quantity (t°, emissions, light …) of a sample, or surroundings. They convert physical parameters into electrical signals.

The starting point for a quality assessment is thus the quality needs, which depend, among other things, on the use case and its requirements. Based on the latter, the concept of data quality can be illustrated by a number of quality aspects of varying importance. The ISO Standard 25012:2008 defines these aspects (or characteristics or dimensions) as a “category of data quality attributes that bears on data quality” (ISO - ISO/IEC 25012:2008 - Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Data quality model 2020). The ISO Standard 25012:2008, in its data quality model, also defines the following fifteen quality aspects: Accuracy, Completeness, Consistency, Credibility, Currentness, Accessibility, Compliance, Confidentiality, Efficiency, Precision, Traceability, Understandability, Availability, Portability, and Recoverability.

After establishing an understanding of the overall quality needs and the data quality characteristics in which the stakeholders of pilot 2.1 are interested in, we plan to involve the different stakeholders of the pilot again more intensively: indeed, in order to assess the priorities of the different data quality elements, we will probably perform additional interviews or workshops. Based on those results, it might be possible to weight the data quality elements to ease the usage of the data quality results.

8.5.4 Expected Benefits

- Decreasing the need of PEMS
- Reducing costs
- Simplifying maintenance
- Complying to specific regulations

8.5.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p).

The following table provides an overview of the identified stakeholders and interests for pilot 2.1:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
farming machines	c						p
machine sensor data	p	c			c		c
efficiency modelling	c	p			c		p
emissions modelling		p					
data quality assurance					p		
operational regulations and reporting	c			c/p			c/p

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.6 Pilot 2.2 - Automated Documentation of Arable Crop Farming Processes

This pilot will develop a Job Cost estimation and prediction for Fertilizing and Spraying Jobs to support the farmers' decision in the field. It will include capturing high precision data, merging with data from farms / machines, and deriving required cost estimation and documentation parameters via data analytics and knowledge management techniques. Having a calculation on job cost calculation enable key to farmers for making a better decision particularly nitrogen application rate. Farmers can get knowledge for cost savings (reduced costs for fertilisation), and Investments into farming activities:

- Environmental benefits (e.g. improvements of the biodiversity, water quality),
- Cost savings for the farmer (reduced costs for fertilisation), and
- Investments into farming activities.

As well as they can get to know the main negative impacts resulting from agricultural activities on water bodies. The over use or misuse of pesticides and other agricultural formaldehyde (such as fertilizers) can allow these chemicals to enter surface and ground water. Progression, evaporation and wind disintegration can carry pesticide debris into the air. From there they can fall in rain to pollute lakes. While most environmental risk comes from the active ingredient in a pesticide, the way its formulation interacts with the environment determines the overall hazard of a pesticide.

The objective is to support farm management with a job cost estimation model based on a data-sharing platform including data analytics and data integration. The model will be derived from an economic analysis of cost and revenues and further historical farm data. An overall aim will be the development of a job cost prediction model to optimize job quality and to increase productivity.

Besides the job costs, the last area of focus will be the enhancement of documentation processes through smart automation of GPS-records combined with background information.

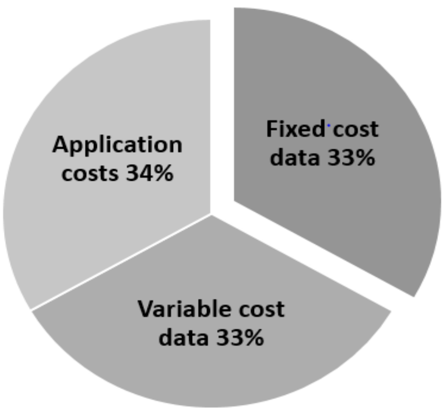
The Pilot will contact 3 farms in Germany with 60 fields in total.

8.6.1 Current Scenario

The costs of a job depend on various factors like the fuel consumption of a machine, labour time and the efficiency of the job. Due to these and more influences occurring over a period of several months, farmers and contractors cannot assess the total cost of a job. Moreover, farmers and contractors have difficulties to decide which job should be done to obtain the highest revenue (e.g. spraying at high cost or losing a part of yield due to disease). In addition, current farming process documentation usually involves a high amount of self-management and time dedication on the farmer's side to fulfil the specific needs of this topic. Most farmers mainly rely on themselves and their resources for documentation impairing quality and quantity of the outcome.

8.6.2 Envisioned Scenario

Agriculture requires an ever-increasing amount of data recording to increase efficiency. For instance, the collection of weather data as well as automated GPS-documentation are important to choose the right timing for a fertilizer application and to meet legal requirements for spraying jobs. Future farming processes that are supported with this pilot solution allow for automated documentation based on the movement and circumstantial data of the process itself. The job cost estimation derived from the documented data will help the farmer to learn where he or she can optimize the revenue. This information will be helpful to support future application decisions.



Total job cost	**1500**
Fixed cost data	500
• *Fixed machine cost* • *Fixed labor cost*	225 275
Variables cost data	500
• *Variable machine cost* • *Variable labor cost* • *Services*	200 200 100
Application costs	500
• *Spraying* • *Nitrogen application*	250 250

8.6.3 Approach

In this pilot, two main aspects will be developed for the farmers, i.e. "Job cost calculation and prediction concepts" and "Automated documentation of arable crop farming processes". These two parts are further supported by a "data quality assessment service" - the third contribution of this pilot.

John Deere focus on job cost calculation for spraying and fertilization applications. m2Xpert focus on pilot 2.2 for automated operational job recognition of farming processes and automated documentation in farm management systems. Fraunhofer IESE will develop a method for assessing data quality in the context of agricultural data.

The focus of the job cost calculation will be on fertilization and spraying applications for winter wheat. These jobs are done several times in the year and will therefore deliver more data than seeding or harvesting, which are only executed once per field. For the development of a job cost estimation model, it is necessary to concentrate on two similar jobs, since the number of influencing factors for all jobs concerning farm work would be too high to include in one model. For the development of an automated documentation tool, the detection of the difference between fertilization, spraying, tillage, and seeding jobs will be the most challenging part of job identification. It is based on sensor data from machines and external sensors such as satellites (e.g. sentinel) and on data from weather stations. This information is intelligently linked and interpreted in the respective context such as location, time, activity or crop.

8.6.3.1 Job cost calculation and prediction concepts

The data used for job cost calculation is as follows:

- Fixed cost data
- Fixed machine cost: Sum of fixed machine costs
- Fixed labour cost: Sum of labour costs
- Variables cost data
- Variable machine cost: Sum of variable machine costs
- Variable labour Cost: Sum of labour costs
- Service: Sum of services costs
- Application costs
- Spraying: Sum of spraying applications costs
- Nitrogen application: Sum of nitrogen applications costs

Measuring the success of decision is a crucial task that develops the farmer understanding for optimizing the decision further. The enabler of a decision support system (DSS) for the farmer is the calculation of job costs. Measuring a sequence of the job costs helps the farmer to evaluate his decision within that sequence. Since farmers deploy AutoTrac machinery (e.g. John Deere Tractors) technology in order to apply his decision in the field a vast amount of data is generated. Such data contains location (latitude and longitude) and attribute information that represents information such as name of the application, date, and amount of applied rate. Indeed, Global Navigation Satellite Systems (GNSS) provide autonomous geo-spatial positioning information. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision using time signals transmitted along a line of sight by radio from satellites. This data is produced once the farmer performs an operation in the field. The data is normally transmitted via a 4G network to the *my John Deere* operation Centre that utilized a cloud service for data storage. Afterward the data will be available in ESRI shape file format.

The calculation of job cost in relevance of the above information will be done by the following function:

$$C = \sum_{i=1}^{n} x_i \;\; i = 1,2,3, \ldots, n$$

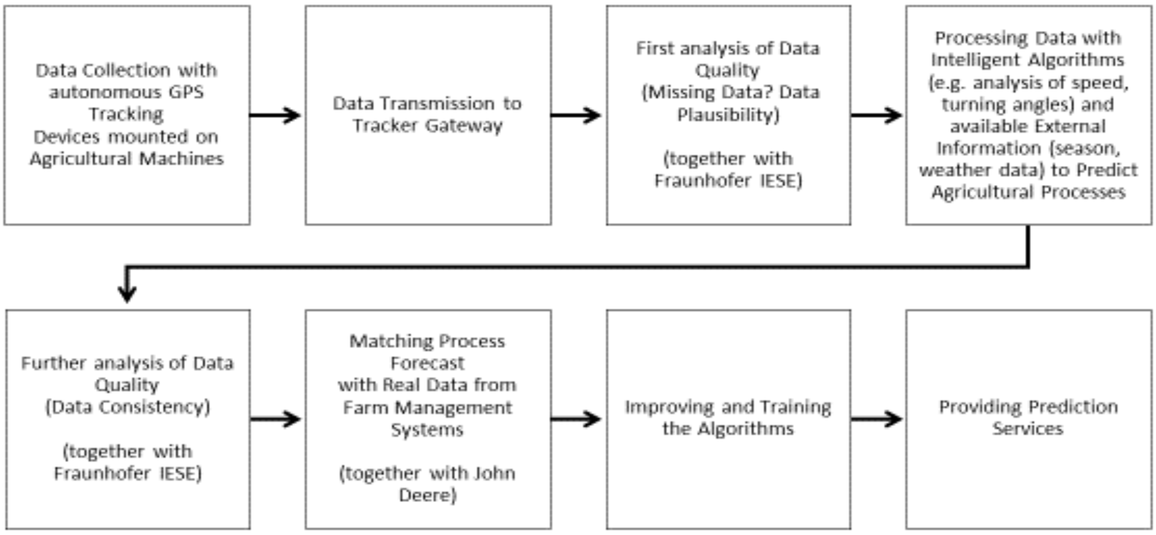
Where C is the sum of all costs and, x_i and n are each feature dataset defined above and number of feature dataset respectively.

The output can be for the total cost for the given farm, and per field costs for that farm.

This information provides the farmer a better insight on the costs and support him on making decision for further investments.

8.6.3.2 Automated documentation of arable crop farming processes

Position and movement data are analysed for automatic process identification. Other external data like the seasonal date of measurement for estimating the relevant process season and weather data or satellite images for checking the plausibility of processes are added. The system is to make process forecasts for automated documentation. Today, agricultural processes are often documented with a considerable time lag before they are carried out. This leads to inaccuracies. The aim is to achieve a process forecast that is as accurate as possible, which largely eliminates the need for manual documentation. The process looks like this:



8.6.3.3 Data quality assessment

In general, we plan to develop the data quality assessment component in pilot 2.2 as outlined below:

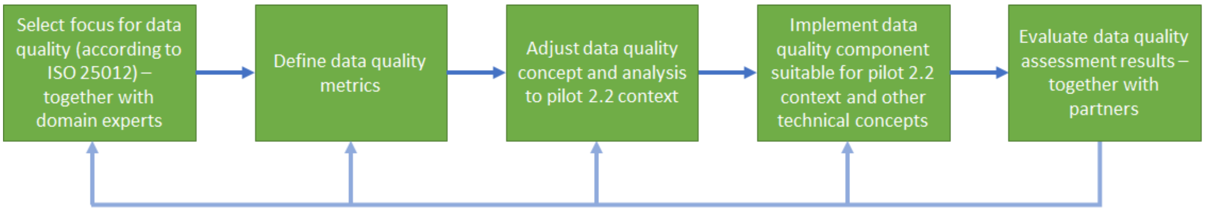


Figure 18: Data quality assessment component in pilot 2.2

The starting point for a quality assessment is thus the quality needs, which depend, among other things, on the use case and its requirements. Based on the latter, the concept of data quality can be illustrated by a number of quality aspects of varying importance. The ISO Standard 25012:2008 defines these aspects (or characteristics or dimensions) as a "category of data quality attributes that bears on data quality" (ISO - ISO/IEC 25012:2008 - Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Data quality model 2020). The ISO Standard 25012:2008, in its data quality model, also defines the following fifteen quality aspects: Accuracy, Completeness, Consistency, Credibility, Currentness, Accessibility, Compliance, Confidentiality, Efficiency, Precision, Traceability, Understandability, Availability, Portability, and Recoverability. For example, in the case of pilot 2.2, data quality characteristics such as plausibility, completeness and consistency are likely to be relevant for the GPS data.

After understanding the overall quality needs and the data quality characteristics in which the stakeholders of pilot 2.2 are interested in, we plan to involve the different stakeholders of the pilot again more intensively: indeed, in order to assess the priorities of the different data quality elements, we will probably perform additional interviews or workshops.

8.6.4 Expected Benefits

Given the many factors influencing a profitable job application, the above-mentioned approach contributes to three major benefits: On one hand, job cost prediction has the potential to increase farmers and contractors' productivity. In addition, the automated job documentation and collected weather information will improve decision support. Finally, automated documentation will be serving both time efficiency and precision for a process.

Measuring the success of decision is a crucial task that develops the farmer understanding for optimizing the decision further. The enabler of decision support system (DSS) for the farmer is the calculation of job costs. Measuring a sequence of the job costs helps the farmer to evaluate his decision within that sequence. Since farmer uses advanced machinery technology in order to apply his/her decision in the field a vast amount of data is generated. Such data contains location (latitude and longitude) and attribute information that represents information such as name of the application, date, amount of applied rate. These data is produced once the farmer preforms an operation. The data is normally transmitted via a network to my John Deere operation centre that utilized a cloud service. Afterward the data will be available in ESRI shape file format.

8.6.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 2.2:

Interests	Stakeholders						
	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
job cost estimation modelling	c	c/p			c	c	c
historical farm data	p				c	c/p	
data exchange platform	c				p		
data brokering service		c			p		
GPS Tracker	p		p		c		
Machine Sensors	p				c		p
data quality assurance		p			p		
job cost reporting / prediction	c				p		

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.7 Pilot 2.3 - Data Brokerage Service and Decision Support System for Farm Management

This pilot will establish a trust based and compliant data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer, and that will include both a technical platform and advisory services that will ensure easy adoption of data and technology by farmers. The objective is to use data integration, analysis and visualisation applications for a decision support system.

The Pilot will initially be deployed in 6 sites in the following countries:

- Czech Republic – 2 sites
- Poland – 2 sites
- Latvia – 1 site
- Norway – 1 site

8.7.1 Current Scenario

Farmers are using many technical systems for:

- Farm work organization.
- Control of farm processes and control of machines.
- Farm life organization.
- Data analysis and data preparation.
- And for data storage.

Many times, these systems are made by several produces, are using independent communication protocols and based on it – system of all devices are not able to organize the farm data brokerage. Based on this reality description it is necessary to look for solutions which will improve this status. It is necessary to look for common solution when farmer will be able to have access to the complete data.

8.7.2 Envisioned Scenario

There is already existing a large number of suppliers for farming related data. It varies between data from machinery, satellite data, meteorological data, Land parcel information systems, water bodies data, erosion data soil data, etc. This data is offered by different systems, different data models and different API´s. For farmers it is important to have access to the complete data, but they are not able to provide integration of this data.

8.7.3 Approach

Farm data brokerage establishes a trust-based and compliant data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer. This data market will consist of both a technical platform and advisory services that will ensure easy adoption of data and technology by farmers

8.7.4 Expected Benefits

Expected benefits are to use data integration, brokerage service, analysis and visualization applications for a decision support system on the farms. Farmers will have access to the complete data, and they will be able to provide integration of this data in on support, information and decision-making system. Farmers currently do not have this option. This farm support, information and decision-making system will have positive influence on current waste eliminations, increasing of efficiency, time, effort and expenditures saving.

8.7.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 2.3:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
data exchange platform	c	p	p		p	p	
reports	c			c	p		
reports, knowledge base	c				p		
farming machine data	p						c

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.8 Pilot 2.4 - Benchmarking at Farm Level Decision Support System

This pilot aims at developing services to support the benchmarking on the productivity and sustainability performance of the farms, leveraging and extending existing decision support system for farmers (DSS). This will involve monitoring different conditions and parameters affecting such indicators, collecting the data and integrating it in a unified layer accessible by the DSS.

The Pilot will be deployed in 10 sites with different farms sizes:

- 5 small farms
- 3 medium farms
- 2 big farms

8.8.1 Current Scenario

Jan Nowak (52 years) is a farmer and runs a medium-sized farm, has a secondary agricultural education and many years of experience in farming. On the farm with an area of about 30 hectares, only plant production is carried out. The main crops are: winter wheat (10 ha), winter rape (10 ha), sugar beet (5 ha) and spring barley (5 ha). The yield level of cultivated plants is above average, i.e.: winter wheat - 70dt / ha, winter rape seed - 40dt / ha, sugar beet - 700dt / ha and spring barley - 50dt / ha. This ensures a high cultivation culture and good soil conditions. The farm is dominated by soil classes III and IV. The farm is equipped with the necessary machinery and equipment for growing plants, which makes it self-sufficient in this respect. Farmer Jan earns an income that allows him to support his family and make the necessary investments, but he does not have a full overview of the economic situation of his farm. In addition, he makes some calculations, but they are not very precise. The farmer is aware that other farmers also perform well, but due to the lack of appropriate tools it is not possible to compare them. Jan does not know if and which his actions are optimal and which can be improved.

8.8.2 Envisioned Scenario

Jan Nowak, the same farmer, gets a new tool from his advisor Marek. Marek explains to Jan, that he can compare his farm situation with the other farmers from his region and similar production profiles. Jan collects data from his farm and enters it into the system using a web browser. Some of the data could be also taken from Jan's farm devices if possible (he is consulting it with platform technical support). His advisor checks that all needed data is in the system. Now the farmer can compare his results with the results of other farms thanks to the new tool, which enables:

- determining the type and economic size of his farm,
- making calculations according to a uniform scheme enabling analysis of the results obtained,
- comparison of your results with the results of farms of similar agricultural type and economic size,
- making rational decisions regarding your business.

After some time, Jan calls to Marek and asks him about the best fertilizer (recommended from outside database for example FOODIE database) for the next treatment. Marek, thanks to integration with farm data collected by DEMETER, checks Jan's farm situation and gives advice to Jan.

8.8.3 Approach

Provision of a simple to use benchmarking system that would allow the use of ICT and IoT technologies in practical management and decision support, with a focus on data integration. This will be done by adopting Linked Data as a federated layer, complemented with security mechanisms, and implementing computational benchmarking models with interfaces that reuse/extend existing decision support and farm management systems (as an added value feature).

8.8.4 Expected Benefits

Facilitation of farm management at various levels of production volumes and types is expected to help with decision making for farmers by using a broad spectrum of data. This will also improve farmers' access to comparable data from his own farm with others. Data will be aggregated at the farm advisory system level. All activities are also aimed at increasing the knowledge of farmers and accessibility of digital skills.

8.8.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 2.4:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
economic data input and analysis	p	c			p		
DSS Farm Management Models		c			p		
Agriculture Cloud			p				
Farm accountancy data network					p		
Farm Management System Software	c	p				p	

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.9 Pilot 3.1 - Decision Support System to Support Olive Growers

The efficient management of olive orchards requires complex decision-making processes because of the uncertainty and risk associated with olive fruit and olive oil production – due to weather conditions, soil variability and pest infestations. In this sense, Decision Support System (DSS) and modelling may contribute to ameliorate on-farm agronomic management and decision process, predicting the likely occurrences of specific crop-related attributes in advance. The quality of decision-making plays an important role, even in uncertain situations. Despite DSSs may help farmers in implementing climate smart agricultural practices, their use among olive growers is limited due to the lack of user-friendly interfaces and easy-to-interpret outcomes.

The aim of this pilot is to develop and demonstrate a DSS for olive growers, advisers and agri-food processors to address common issues associated with olive tree growing and olive oil production, including integrated pest management, fertilizer use and irrigation needs. The DSS will integrate in-field sensors data, remotely sensed data, a modelling platform and a farm management system, combining weather patterns and soil information with crop traits, to foster the sustainable production of olive orchards.

8.9.1 Current Scenario

Agricolus© OLIWES is a cloud ecosystem to support olive growers, agronomists, agri-food processors and other agricultural operators in optimizing agronomic practices with the most modern technologies of data collection, analysis and visualization, combined in a user-friendly interface.

The functional characteristics of Agricolus© OLIWES are divided in the following areas:

Olive orchard management: tools for the governance of the farm including the management of farm centres and fields, integration of agro-meteorological data from different providers, recording of field operations and field work assignments (fig. 19):

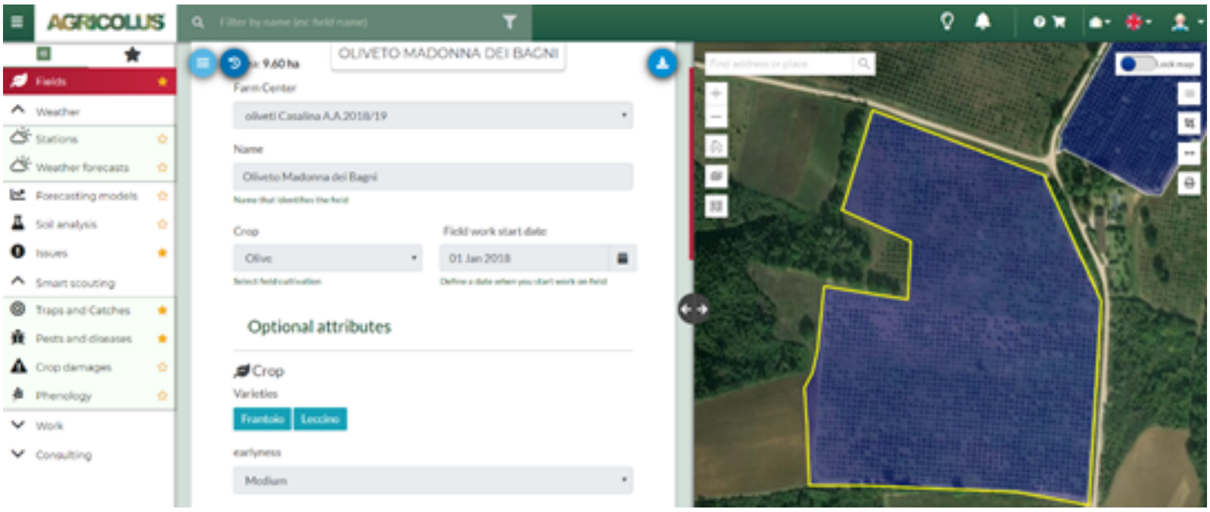


Figure 19: Page of field management in AGRICOLUS OLIWES, section fields

Scouting support: tools for pest and damage monitoring, soil sampling and olive phenology monitoring. The tools are also available in a mobile app.

Models: integrated pest management models for olive fruit fly, olive tree phenology model, water balance model to estimate irrigation requirements, nitrogen balance model to assess olive orchard nitrogen needs (fig. 20):

Figure 20: Page of visualization and description of the water balance model for olive in AGRICOLUS OLIWES, section forecasting models.

Remote sensing: analysis and elaboration of remotely sensed data to provide indices and maps to evaluate water stress (e.g. NDMI).

Decision Support System: dashboard for the visualization of the whole framework and structured in decisions to be taken for pest control, irrigation, and fertilization with tools able to merge the field data, models and remote sensing.

8.9.2 Envisioned Scenario

DEMETER will allow the integration of Agricolus© OLIWES with other solutions and technologies provided by other partners. This will foster the adoption of data coming from different sources (field sensors, open source weather data, open spatial data, IoT devices) to deploy integrated data-model solutions to be tested in the pilot. Field-specific model and sensor data can be processed and integrated in the platform to deliver tailored advices to farmers and advisors on irrigation and fertilization requirements and scheduling, as well as integrated pest management.

Data analytics and knowledge management systems will be applied to data coming from the use and test of Agricolus© OLIWES in different environmental and farming conditions, through the adoption of technology-based solutions to finely determine olive orchard needs, with the aim of achieving sustainable production targets.

To compare the sustainability production targets of farms, benchmarking tools developed within DEMETER will be tested in the farms engaged in the pilot about their agronomic, environmental and economic performance. FMIS of AGRICOLUS OLIWES allows the registration of data such as of crop yield, operations, amount and type of fertilizer used in each field, volume of water used for irrigation, pesticide use, other farm economic data, required for benchmarking purpose. We consider of crucial importance internal benchmarking (compare the performance after the adoption technologies, with the previous) and with neighbours (average of farms belonging to the same pilot).

8.9.3 Approach

The pilot aims to deploy and configure Agricolus© OLIWES in selected olive farms of three countries to address different climatic and farming conditions:

- Italy – medium size farms in Umbria and Tuscany regions belonging to Assoprol association;

- Greece – medium size organic farms in Crete island followed by Agroecologiki;
- Turkey – a set of farms, in Izmir and in Balikesir region, followed by Te-Ta.

8.9.4 Expected Benefits

The expected benefits for farmers and advisors are:

- the optimization of input use due to the application of data driven decisions about water and nutrient management, remote control of olive grove stress and in-field sensors, differentiate the needs across the different olive groves of the same farm and within the same field;
- support in the application of integrated pest management, such as forecasting models to apply preventive measures in the integrated pest management of olive groves, automatic traps, tools for pest monitoring;
- long term data record for time series analysis for tailored advice, ICT tools for sustainable olive grove management;
- comparing farmer performance (agronomic, environmental, economic) and learning from comparison, in order to improve and ameliorate behaviour and working activities.

8.9.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 3.1:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
soil and crop information	p	c	p				
remote sensed data	c	p	p				
interoperable interfaces	c	p	p				
soil parameter sensors	c	c	p				
weather forecast service	c	c					
model for efficient use of resources	c	c/p					
olive fruit fly forecasting models	c						
fertilization requirements model	c	c/p					
irrigation requirements model	c	c/p					
decision support platform	c	p					

Identified stakeholders and interests for pilot 3.1- continued:

Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
knowledge base					c/p		
kpi data export	p	c		c	c		
benchmarking report	c	c/p			c/p		
marketing label / tracing	p	p	p				c
marketplace	c/p	c/p	c/p	p			c
knowledge base	c/p	c/p	c/p	p			c

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.10 Pilot 3.2 - Precision Farming for Mediterranean Woody Crops

This pilot aims at promoting technology, methods and IoT solutions to optimise precision farming practices of Mediterranean Woody Crops (Apple, Olive and Grape), considering the small farmers' economic constraints. The proposed solutions (IoT and Ground Robots) will enable a more efficient usage of inputs such as water, energy, macro-nutrients, and pesticides, thus increasing the profits of small farmers and reducing their environmental impact. The objective is to support real-time monitoring and control of plants, water supply and nutrients, using IoT Sensors and Agricultural Robots on the field for phenotyping, as well as enabling precision-spraying and through the usage of satellite/aerial imagery for yield potential estimation.

The Pilot will be deployed in 5 sites in Portugal:

- 2000 farmers from FENADEGAS association, with 27.123 ha of vineyards
- 4 intensive IoT farm sites: 2xVineyards (10ha), 1xOlive Groves (1ha), 1xApple trees (2ha)

8.10.1 As is scenario

The Mediterranean woody crops owned by medium/small farmers have limited access to technology, due the associated technology costs and the low levels of systems interoperability. These farmers need plug-and-play, cost-effective and modular technology that easy to use and install.

8.10.2 Challenge or to be scenario

Mediterranean Woody Crops have been severally affected by the climate changes (water scarcity), pests and diseases. Besides, most of these farms are small, low on profit and technology, and face high labour costs. These farmers need simple, intuitive and cost-effective technology to help them overcome climate changes, pests and diseases, and become more profitable by reaching full concept of smart and precision agriculture.

8.10.3 Approach

To this end, the pilot aims at supporting better knowledge about crop development, pest and diseases and soil state, as well as improved solutions for agricultural practices such as pesticide and fertilization application, through the usage of cost-effective IoT solutions and the upgrade of conventional machinery and technology.

8.10.4 Expected Benefits

This approach will enable a more efficient usage of inputs such as water, energy, macro-nutrients, and pesticides, increasing the profits of small farmers and decreasing their environmental impact, by reducing the spraying losses more than 20%, the irrigation water consumption approximately 10%, and the NPK over dosage in 15%.

8.10.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 3.2:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
soil and crop information	p	c	p				
interoperable interfaces	c	p	p				
soil parameter sensors	c	c	p				
real time monitoring water supply	c	p	p				
weather forecast service	c	c					
model for efficient use of resources	c	c/p					
fertilization requirements model	c	c/p					
irrigation requirements model	c	c/p					
decision support platform	c	p					
knowledge base	c/p			c/p	c/p		
kpi data export	p	c		c	c		
benchmarking report	c	c/p			c/p		
data exchange standards	c	p	c/p				c
marketplace	c/p	c/p	c/p	p			c
knowledge base	c/p	c/p	c/p	p			c

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.11 Pilot 3.3 - Pest Management Control on Fruit Fly

This pilot aims at providing a set of tools to monitor and manage the Mediterranean fruit fly (Ceratitis capitata) which is dangerous pest with a wide range of distribution and host plants. Automatic capture traps and remote sensing technologies will be employed to predict and support in taking decision and tested in citrus farms in Valencia region. The Pilot will be deployed in Valencian Community region with more than 170.000 hectares involved.

The Ministry of Agriculture in the Valencian Community has a network composed of 938 Nadel traps that are reviewed weekly. Nadel traps consist of a white container in which a male sex attractant and an insecticide pill are introduced. Adults fall into the trap, are captured and die.

The monitored citrus area covers more than 170,000 Hectares, so there is a work team composed of 7 field inspectors who review the traps weekly. All the collected catches are sent to the Evolutionary of Moncada (Valencia), where two laboratory assistants identify and count the wild and sterile flies.

In addition to knowing the population levels throughout the year, the General Monitoring Network serves to evaluate the proper functioning of the Sterile Insect Technique Program, which runs in the Valencian Community. In this program, sterile flies are set free in the citrus zone by means of small planes and later their dispersion, longevity and proportion are evaluated through the recaptures obtained in the Monitoring Network. Also, it would be very important to know the information about the maximum activity of flies during the year and depending on the latitude, altitude and climatic conditions in order to define sterile male liberation as it must coincide with the moment of maximum activity of the fly in the field.

The development of automatic counting traps would allow a high reduction in workers and vehicle costs. It would also allow a better monitoring of the sterile males' liberations and therefore a better design of the liberation strategy, and a general improvement in the results of the pilot.

8.11.1 As is Scenario

In this pilot different trap manufacturers are developing automatic counting devices for the control of mosquitoes, moths or dipterans plagues. These traps are mainly based on two principles: a) Periodic photographs and image analysis of the obtained captures, b) sensors for detecting insects when they go inside the trap. Both technologies send the information to a management system. Just as the first option obtains information at regular time intervals, the second obtains precise information when the flies enter in the trap. In both cases is used the same attractant that in conventional traps. It could be interested to research in automatic trap based on infrared LED sensors.

8.11.2 Envisioned Scenario

It is important to research in the methodology and technologies used for the *C. capitata* monitoring as the last significant changes have been the introduction of the use of the GIS and the databases for effective information management.

The sterile fly is easily identifiable thanks to the colour emitted by fluorescein when it is illuminated with ultraviolet light. The inclusion of a sensor to detect such coloration could allow the sterile flies identification in the field. This technology could also be used for routine laboratory quality controls or for other species such as the tiger mosquito (Aedes albopictus).

On the other hand, by means of a modification in the design of the trap, a trap version without an insecticide tablet can be made so that adults can be captured but do not die. In this sense, the flies could be analysed for quality controls (longevity, copulation competitiveness ...).

In DEMETER different technologies can be studied and investigated as infrared LED sensors, identification and meteorological data sensors, facilities for power supplies of the traps, integrated GPS receivers, facilities for automatic collection and count, emission of data, weatherproof materials, etc.

8.11.3 Approach

The pilot aims to support better knowledge about Mediterranean fruit fly and improve solutions for plague management practices such as about pesticide and fertilization application, by using cost effective IoT solutions and upgrading conventional technology and systems.

8.11.4 Expected Benefits

The automatic counting traps would mean an important reduction in the staff and displacements costs. These savings would increase the trap density according to the levels indicated and recommended by the International Atomic Energy Agency (IAEA).

Another great benefit is the possibility of having real-time capture data would allow to evaluate the distribution and longevity of sterile males in the field as well as to better adjust the liberation strategy of males depending on wild population dynamics. Also, the automation of the process will allow sending real time data to the farmers related to status of the pest in the field.

8.11.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 3.3:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
interoperable interfaces	c	p	p				
weather forecast service	c	c					
fruit fly sensors / automatic traps	c	c/p	p				
GIS model fruit fly	c	c/p					
Wireless data transmission technology	c	c/p	p				
GPS technology for automatic trap	c	c	p				
fruit fly counting algorithm	c	c/p	c				
decision support platform	c	p					
knowledge base	c/p	c	p	c/p	c/p		

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.12 Pilot 3.4 - Open Platform for Improved Crop Monitoring in Potato Farms

This Pilot aims at integrating field machinery data with remote sensing, meteo and soil data into the WatchITgrow (WIG, watchitgrow.be) platform. The field data (planting date, planting distance, detailed yield information) is an important source of information for the calibration and validation of the analytical crop models in WIG that use satellite data, meteo data and soil information as inputs to model crop growth and predict yields. The in-field data could allow the development of a purely data-driven model instead of fine-tuning physical models. The enhanced crop growth models will be used to give advice to farmers for the optimization of field management practices (optimal harvest date, variable rate haulm killing, variable rate fertilization, irrigation advice).

8.12.1 Current Scenario

WatchITgrow uses remote sensing data (Sentinel 2, Copernicus program), combined with local meteo and soil data, to inform farmers via a user-friendly web application on the status of their crops and on expected yield. The crop model is based on a detailed physical model that to needs to be manually fine-tuned for every species and variety, using a limited set of ground truth data. This lack of sufficient ground truth data (measured yields, crop variety, exact planting date) hampers the calibration and validation of crop growth models and the provision of specific advice on field management practices.

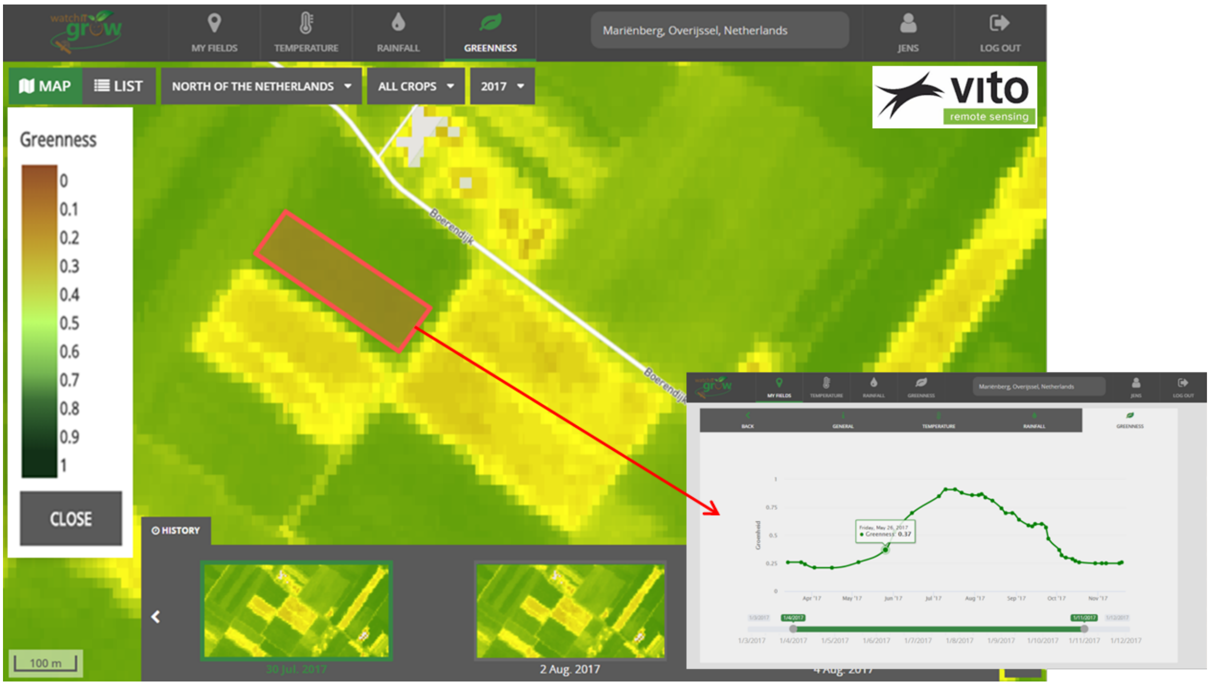


Figure 21: WatchItGrow web application for visualization of Satellite data and crop growth data

8.12.2 Envisioned Scenario

Using detailed data from the machinery in the field (detailed yield information, planting dates), the physical crop model can be replaced by a purely data-driven approach using machine learning techniques. The enhanced yield model will be embedded in the WatchITgrow platform to give tailored advice to farmers for the optimization of field management practices (optimal harvest date, variable rate haulm killing, variable rate fertilization, irrigation advice).

Figure 22: AVR Puma 4.0 potato harvester with GPRS/4G data connection

8.12.3 Approach

AVR Connect is the recently started IoT cloud platform that collects data from the field machinery (potato planters, yield sensors on the potato harvesters) using 4G communication, and makes the data available to third parties. Geotagged yield data will be collected at a frequency 1Hz, which leads to very detailed yield maps.

- AVR Field machinery data, automatically uploaded to AVR Connect Cloud using 4G:
  - Geotagged and timestamped planting data (planting distances)
  - Geotagged yield data collected at a frequency of 1Hz using yield sensors on the field machinery
- WatchITgrow data
  - Remote Sensing data: NDVI and FAPAR timeseries per field, using a combination of Sentinel-1 SAR data and Sentinel-2 images to create uninterrupted timeseries with daily values, also for cloudy days (VITO “CropSAR” service)
  - Soil type from soil type maps for the Flanders region
  - Meteo data at 5x5km resolution from the Belgian National meteo service (KMI)
  - User input on field activities (crop protection, crop damages, fertilization)

In this pilot, data from both the AVR machinery (potato planters and harvesters) and the WatchITgrow platform will be made available as DEMETER components to develop data-driven yield prediction and crop status models using Machine Learning. This task will be closely linked to the developments on AI-based decision making from DEMETER WP 4. The enhanced crop status and yield prediction models will help to give specific advice to farmers on how to optimize field management practices.

8.12.4 Expected Benefits

This pilot expects (i) to gain better insights on the interaction of crop, meteo, soil parameters and field management practices, and their impact on the final yield and (ii) to provide advice to farmers on how to optimize their current field practices in order to increase their yields in a sustainable way.

8.12.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 3.4:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	General Public
farm data: potato planting date, variety, harvest yields, irrigation info, local meteo, soil info	p	c	p			c	
interoperable data interfaces	c	p	p				
IoT sensor data: Soil info, local meteo	c	c	p				
Earth observation Service: Web coverages services, Timeseries services	c	c	p				
weather forecast service	c	c					
model for efficient use of resources	c	c/p					
yield prediction algorithm	c	p					
irrigation requirements model	c	c/p					
decision support (platform)	c	p			p		
knowledge base	c/p			c/p	c/p		
GPS tagged info on potato planting and harvesting	p	c		c	c		
benchmarking report	c	c/p			c/p		
IoT Machinery data	p	c	p				
General Farm data	p	c	c		c		
Influence legislation and trade	c			p	p		
data exchange standards	c	p	c/p				c
knowledge base	c/p	c/p	c/p	p			c
kpi data export	p	c		c	c		
benchmarking report	c	c/p			c/p		

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.13 Pilot 4.1 - Dairy Farmers Dashboard for the Entire Milk and Meat Production Value Chain

This pilot focuses on a 1) farmer's digital dashboard for a better view/outlook over the farm activities and the farmer's cooperation with both private and public actors, more efficient use of digital tools the farmer applies and better and more customized decision support for each farmer, including 2) decision support based on AI Machine learning from sensor data.

The focus is primarily on dairy farms but the concept will include all types of farms in Norway.

The main partners in the pilot are as follows:

- **Agricultural Dataflow** - a Norwegian company that develops and maintains standards and infrastructure to streamline central data flows and provide better decision support for farmers and the agricultural industry in Norway.
- **Mimiro** - a Norwegian technology company that works with a data platform and digital solutions for more efficient and environmentally friendly milk and other food production.
- **SINTEF** - a large, independent research institution in Norway with around 2000 employees and 1400 researchers. The institute involved in DEMETER is SINTEF Digital, which provides expertise on the relevant technologies as well as innovation management.
- **TFoU** - a small research company in Norway with 15 employees in social sciences and expertise in analysing user needs for farmers and other relevant actors in the society.

Agricultural Dataflow will provide a Farmer's Dashboard supported by the Agricultural Dataflow platform demonstrating interoperability interfaces for different digital farm systems in the value chain. Agricultural Dataflow will build data infrastructure and models of farmers dashboard in a co-creational process based on the Agricultural Dataflow infrastructure today, specially related to the companies' authentication and authorization systems, with farmers and related partners and industries in Norway. Mimiro is one of these partners.

Mimiro will provide AI-based Prediction systems for milk production using data from sensors on animal milk production and health, collected and provided through the Mimiro data collection platform, where the farmer will own his own data. They will work with the data infrastructure from Agricultural Dataflow and get their own data infrastructure to function and facilitate efficient production of milk and meat. The research partners TFoU and SINTEF will work with user needs and responses from the farmers to the provided solutions, as well as wider stakeholder involvement, contribute to the exploration of innovation potential and new business models, and assess economic and social benefits for the farmer, the involved partners, the agricultural sector and the society.

Since it will be important to involve many different partners, hopefully both in and outside Norway, the multi actor approach in DEMETER is a preferred tool. All partners in the pilot (Agricultural Dataflow, Mimiro, TFoU and SINTEF), will have the responsibility of involving other partners/contributors from their respective networks and work fields. Farmers in Norway own both Agricultural Dataflow and Mimiro through the farmer-owned industry. Hence, the two companies are in contact with many of the key stakeholders in Norway, and they will involve these in the pilot.

TFoU and SINTEF will contribute with involvement of farmers/end-users in Norway, evaluate versions of the farmers dashboard, produce easily understandable information from different stages in the pilot and complement existing research of best practices.

- Standards used: ISO/IEC AWI 21823 Internet of Things; ISO/IEC 19944:2017 Cloud computing; ISO/IEC 19941:2017 Cloud computing; ISO/IEC AWI 23053 Artificial Intelligence (under development); ISO/IEC 2382, Artificial Intelligence; ISO/IEC 29182, Sensors; Recommendations from AIOTI WG03.
- Data exploited: Cow sensor data – feed, temperature, Movement, Milking robot production data, Milk fat, Economic data.

We will develop digital solutions for more efficient and environmentally friendly food production. During 2019, we will also launch new apps for Norwegian farmers, with easier registration and insight to continuously improve production. At the same time, we are building a digital ecosystem for agriculture, for external suppliers, researchers and advisors. Mimiro's platform already represents a significant user base, as today, active users are existing solutions. Based on TINE and Felleskjøpet, Mimiro is established to take on the company's long-standing experience. Our mandate is to think again with our old history, to develop solutions for tomorrow's agriculture. Mimiro will develop services that make the farmer's data relevant, in completely new ways. The goal is to create agility in agriculture by linking the various players together.

8.13.1 Current Scenario

The dataflow for farmers is a big challenge and opportunity for business development in the sector. Today's digital solutions for agriculture do not speak good enough together and are not largely based on the needs of the individual farmer. The farmer has a lot of app's, ICT-programmes, farm management systems, digital solutions and dashboards to cope with and all actors the farmer collaborate with want to have a part of the farmers attention and "clicks/likes/touch". The farmer gets lost in a wild digital landscape and misses essential information and the overall picture for his farm management.

Good forecasting models for milk production are essential to be able to plan and optimize production in terms of economy, animal numbers, milk quality and feed production. Forecasting models must be developed at different aggregated levels from single animals, herd groups, herd level, regional level and national level.

Nevertheless, the starting level is the individual animal and that means you need data from single animals. In Norway a very extensive data material is available through the national herd recording system (NHRC). The NHRC includes individual cow data related to milk performance, milk quality, health, genetics and feed intake. The NHRC covers 98.6% of the Norwegian cow population and 98% of the dairy farms. In the last 15 years there has been a major technological change in Norwegian dairy production and today about 50% of the cows are milked by a milk robot (AMS). Mimiro has developed a data platform that receives daily milk production from the AMS and this means a 80-fold increase in data points compared to today's NHRC.

8.13.2 Envisioned Scenario

Agricultural Dataflow is in the process of designing a "farmers' dashboard" that will integrate various stand-alone dashboards, farm management systems, app's and ICT-programs for the farmer in a common framework. The aim for the solution is to:

- present essential decision support for individual farmers and be an entrance to other and more specific farm management systems which the farmers use seeking to optimize their farm's productivity.
- streamline the digital everyday life for the farmer and try to get better collaboration between different web-sites, app's, programs etc the farmer uses
- get better interaction between private and public digital interfaces for the farmer

The company also develops a system for data collection, modelling and calculation of greenhouse gas emissions on farm level. This tool will also be a part of the overall picture in the farmers dashboard and will be integrated with other farm management systems for optimizing the farm productivity with the Agricultural dataflow infrastructure.

Mimiro develops products and services based on the optimization and analysis of the farmer's data, solutions that are easy to use in the daily life of the farm while providing concrete advice the farmer can act based on, rather than displaying information. And an important principle is fundamental: The farmer owns his own data. Mimiro creates an ecosystem for data that researchers, advisors and external service providers can benefit from. Mimiro will collaborate with anyone who adds data or another user value. Data that the farmer wishes to share anonymously will be available to external suppliers, thus providing better services back to the farmer.

Increased data access will strengthen the possibilities for developing effective forecasting models with a higher degree of precision and accuracy. Mimiro's experience with the use of ML and AI makes it interesting to use these methodologies in developing the next generation of milk forecast models. The objective of this sub-project is to develop ML based milk forecast models as the basis for a farmer's planning and decision support tools. In the project, conceptual work will also be carried out with farmers to ensure user participation and a high value for the farmer. We will also study how forecasting data can be integrated with other models/applications for economy, feeding and feed production.

8.13.3 Approach

Focusing on user needs and the MMA approach, the goal is to build digital infrastructure, develop a farmer's dashboard and develop analysis that contribute to more effective production for farmers and related business.

8.13.4 Expected Benefits

DEMETER is expected to contribute in many different ways when it comes to developing knowledge and solutions:

- What are the main decision variables for each farm and farmer and how can the farmer focus on these variables in one overall dashboard?
- How to put together each farmer «own» dashboard and how can we use the technology making these solutions?
- How to get system suppliers and the partners of the farmers to cooperate and interact sharing data and web-interfaces – competitive and organizational issues?
- What business models can be used and what is the cost-benefit for the farmer, related business and the society?

8.13.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 4.1:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
Dashboard	c	p					
DSS Benchmarking Component		p		c			
DSS System	c	p			c		
Operational data	p	c				p	
Data Hub	p	p		c	c/p	p	

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.14 Pilot 4.2 - Consumer Awareness: Milk Quality and Animal Welfare Tracking

The pilot focuses on implementing an information flow optimization across different actors of the milk supply chain – from farmers to consumers – ensuring the transparency of all stages.

In particular, the information flow optimization includes*:*

- Breeding and milking with a focus on animal welfare and optimization of farm activities;
- Transportation of milk, with a focus on product safety;
- Processing, with a focus on quality of the final product;
- Labelling, with a focus on information to consumers.

The actors involved are:

- **Maccarese SpA**[2], the largest Italian dairy farm (with 1450 Friesian dairy cows, 600 fattening calves and 3.240 hectares of land);
- **Latte Sano SpA**[3]**,** leader within Lazio Region for the distribution of milk and dairy products (also through Horeca channel and GDOs, with a daily collection of 200 tons of milk in the region);
- **Coldiretti**, the largest agricultural organization in Italy and across Europe;
- **Engineering SpA**, the first IT group in Italy and among the top 10 IT groups in Europe;

[2] http://www.maccaresespa.com/
[3] https://www.lattesano.it/

- **RoTechnology**, an innovative SME which designs, develops and validates applications, tools, firmware and hardware components for several markets.

Problem:

The rationale of the pilot is based on three main assumptions. First, quality of milk is closely linked to welfare of animals: an adequate eating and resting of animals will increase milk production and quality, and will lead to increased dairy yields. Maccarese already monitors its animals by using different smart devices which collect data in a scattered way (without an overall vision of animals' welfare). Second, processing companies are interested into milk's quality levels, as they pay to farmers a variable premium, based on pre-defined (on legal basis) quality indicators of milk (these indicators are focused on the hygiene and welfare of livestock, and encourage farmers to produce milk with higher quality). Third, consumers ask for transparency of the food they eat. The pilot aims at connecting these three dimensions creating an optimized flow of information.

Solution:

The pilot intends to optimize the flow of information between the actors involved in their short milk supply chain.

The scope is to integrate the data collected from the breeding farm (Maccarese) in order to use them to give an overview of the most important animal welfare and milk yield indicators. These indicators will be used to give insights on the quality of milk, that is strictly connected to the animal welfare, and will be accessible by the processing company (Latte Sano) through a single and dedicated point of access which will be made available by ENG.

Specifically, Engineering will design and implement:

- an **Animal Welfare DSS** aiming at supporting the most important choices that the breeder has to make in the management of his/her livestock. This DSS aims to provide the breeder with important indicators mainly with respect to animal welfare (i.e. prediction of lameness, mastitis or ketosis) having as input all the data collected in the farm through the already existing devices and the ones acquired within the project. The DSS will have as output a pie chart showing a prediction of the percentage of sick and healthy cows for each pathology and will provide recommended actions to the farmer about how to improve highlighted critical situations.
- A **Traceability DSS** aiming at offer to the processing company a prediction of the milk quality based on data collected by the processing farm. Moreover, the DSS will provide suggestions about what to do to improve critical results.
- **A Benchmarking system** aiming at provide to the farmer and the processing company with a short report showing a comparison of a set of farm's performance indicators (milk yield by cow, milk total yield, milk quality, cow health, nutrition and company productivity) with a set of target values (i.e. average and optimal indicator values from similar/neighbour companies).

Engineering will carry on the activities related to DSS design through a state of the art analysis of the most significant and reliable algorithms, trying to work with other pilots facing the same challenge (identified also thanks to Task 5.5 "Cross-Pilot Coordination, Fertilization and Optimization" and WP4 "Performance Indicator Monitoring, Benchmarking and Decision Support" interaction) to the co-creation of these DSSs that, according a "machine learning" approach, will use the available historical data (if available) produced within the pilot.

The data collected will be included in a traceability system (designed and developed by RoTechnology), to improve communication between actors up to the consumer and increase food liability and trust. Information on animal welfare, origin, etc., can be acquired through an ad-hoc application designed to provide information on a product through the entry of its expiry date as well as on the product label. RoTechnology will bring blockchain technology in order to keep track of shipped goods and to guarantee quality of shipped goods and immutability of daily data.

The pilot results will be disseminated towards farmers' community (by Coldiretti) and exploited in other diary supply chain.

8.14.1 Current Scenario

Maccarese is aware that milk quality is closely linked to welfare of animals and indeed collects a huge amount of data linked to animal welfare monitoring. These data come the following wearable devices for animals:

- **Pedometer** (AfiActII) which mainly monitors the rest of the animal that is strictly connected to the lameness risk. The animal needs rest so it is necessary to monitor its movements to support it in its well-being.
- **Milking robot** that is a device which provides information on electrical conductivity, parameter correlated with the incidence of mastitis.
- **Data Log** devices for temperature control (applied to the animal's vagina) that allows to monitor the temperature of the animal and potentially to regulate the refrigeration of the environment in which they live.

Moreover, Maccarese currently uses **Afilab[4] software** allowing a control on milk quality from the single animal. This software allows to give information related to the relationship between fats and proteins that is closely related to animal health and is used to detect a disease such as ketosis.

Data linked to animal welfare already collected by Maccarese are not exchanged with other actors from the supply chain, so there is no an efficient collaboration and information exchange.

8.14.2 Envisioned Scenario

This pilot focuses on implementing an information flow optimization across different actors of the supply chain – from producers to consumers – ensuring the transparency of all stages. Specifically, it aims to make effective the information flow through the following processes:

- **Breeding and milking**, with a specific focus on animal welfare metrics collection and relative optimization of farm's activities; to this aim, Maccarese has acquired new devices for rumination, eating habits and respiration monitoring (**AfiCollar**[5]) and technologies for the separation of dairy yield (**AfiLab**) to be applied to milking machines (in order to optimize the milk separation process of higher and lower quality already in milking). Engineering will be in charge of data source harmonization for monitoring scopes and to provide ready to use data to the traceability system. Specifically, Engineering will provide a Decision Support System (DSS) to give integrated insights on animal welfare.

[4] https://www.afimilk.com/afilab
[5] https://www.afimilk.com/cow-monitoring/

- **Transportation of milk**: to guarantee the traceability of the milk collected; Latte Sano will install automatic lactating devices (**Milk Box MKII**[6]) on the tank of the truck for Maccarese. This is a device allowing a fully automatic solution for milk composition analysis for payment and dairy herd improvement and for temperature monitoring.
- **Processing**: to optimize the daily samples analysis collection and storage; Latte Sano will install on the machinery, in the processing plant, equipment (**MilkoScan FTIR**[7]) to analyse the characteristics of all milk collected. Engineering will provide a Traceability Decision Support System (DSS) to give integrated insights on the quality of the milk and a Benchmarking system to allow the processing company to compare its performance in term of milk quality with target values.
- **Labelling**: this process is already in charge of Latte Sano; the traceability system will cover all the processes including labelling, with the aim to transfer the final product quality information to the consumer. All the data really relevant for consumer will be made available to the consumers (e.g. milk quality and animal welfare).

8.14.3 Approach

Since quality of milk is closely linked to welfare of animals, it is important to collect all the significant data that can give insights on the life quality of the animals. New IoT devices will be installed, and data coming from sensors already existing on the pilot farms will be integrated in order to implement an information flow optimization, optimize processes and improve communication in the supply chain increasing the food liability and trust.

Deployed solution will be improved and extended using DEMETER defined APIs and data formats to enable its interaction with other relevant IT systems.

Furthermore, the pilot aims to take care of consumer awareness with respect to topics such as: food quality (and relative difference between market prices) and animal respect (to prefer products that do not mistreat animals).

8.14.4 Expected Benefits

DEMETER will provide a solution able to give a series of important benefits for all the actors of the supply chain:

- The breeding farm:
  - Higher quantity of collected data and better use of them by means of platforms integration (optimizing the availability of scattered data in a single access point)
  - Higher quality of milk and fairer price for producers
  - Improvements in milk quality measurements
  - Easy monitoring of animal welfare
- Processing company:
  - Process optimization related to samples analysis collection
  - Greater transparency on milk production and animal health
- Consumers:
  - Higher transparency on product nutritional values, origins and animal welfare
  - Supply chain benefits

[6] http://www.milksampler.com/
[7] https://www.fossanalytics.com/en/products/milkoscan-7-rm

  - Effective and efficient collaboration, relevant information exchange between the breeding farmer and the processing company in the short local chain and between the processing company and the consumers
- Technology providers:
  - Implementing their own solution to support a complete milk supply chain and to experience new collaboration for more complex and complete solutions for farmers and processing companies.

8.14.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 4.2:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
Cow Health Prediction	c	p			c	p	p
Stress Detection	c	p	p		c/p		
Data Hub	c/p	c/p					
Milk Quality Prediction		p			c		
Traceability System	c/p	p	p	c	c	p	c
Benchmarking report module	c				c		
KPI data export	p						
Marketplace	c/p	c/p	c/p		c/p	c/p	p
Knowledge Base - Rules and Regulations	c			c/p	c		

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.15 Pilot 4.3 - Proactive Milk Quality Control

This Pilot will focus on using new and appropriate ICT tools to measure relevant parameters of animal behaviour and physiological status on a continuous, real time basis. This animal behaviour and physiological data will be integrated to develop prediction models of cow welfare and health. A decision support aspect will allow the end-user, e.g. farmer or vet, to identify when intervention to the animal is necessary. This information can then be fed into a welfare and health scoring frame-work which will act as a record of animal well-being standards being met/ exceeded and will ultimately contribute to improving animal well-being standards on dairy cow farms.

8.15.1 Current Scenario

Traditional farming involves management systems based on direct observation of animals and intuitive decision making by the farmer. Larger animal numbers and reduced available time of the farmer are necessitating changes, potentially resulting in less available time to observe and detect welfare and health issues of individual animals. At the same time, societal expectations are increasing in terms of animal well-being and animal health, together with an expectation of significantly lower use of antibiotics in animal treatments. Thus, it is necessary to develop alternative mechanisms to predict welfare and health issues.

Technology now presents a solution by enabling different animal characteristics to be monitored continuously in a real-time manner. This pilot will generate a system capable of providing a continuous status of dairy cow well-being, thus allowing development of a model to predict welfare or health issues, with biochemical tests to confirm health status. Thus, the IoT will be used in establishing a system for the future dairy farm that will

a) predict when an animal is not "functioning" properly;
b) establish a target that e.g. 97% of cows had no significant issue throughout their lactation; and
c) satisfy claims of the well-being of animals.

8.15.2 Envisioned Scenario

The overall challenge is to integrate animal behaviour and physiological data into a welfare and health scoring frame-work with progression to a reference system to increase animal well-being standards on dairy cow farms. In order to achieve this, a number of objectives will need to be achieved. Firstly, the current animal welfare scoring systems that are available internationally will be reviewed. Secondly, different behaviours and physiological states that can reflect or impact on welfare and health of dairy cows will be identified. Thirdly, appropriate ICT tools to measure relevant parameters on a continuous, real time basis will be identified. Fourthly, 'gold standard' measurements/ indicators of welfare and health of cows will be put in place. Fifthly, a data fusion platform where the data from different sensors will be integrated will be created and a predictive model for various well-being characteristics of the cow will be developed. Finally, a well-being audit for dairy cows will be created that may be used as a reference standard to create management systems that improve animal well-being and that may also be used as a reference standard in the marketing of animal product (milk).

8.15.3 Approach

This planned work is associated with animals in an indoor grass-based system. The use of ICT tools for capturing data and monitoring animals has developed faster with indoor systems, i.e. where animals are housed for much of their lifetime.

The overall approach that will be used in this work is as follows: A number of cow behaviour characteristics and physiological states that can reflect or impact on welfare and health of dairy cows will be identified. This will be achieved through the knowledge of informed research and extension personnel. Example behaviour characteristics to be monitored may include cow feeding time, rumination time, activity and movement. Production characteristics to be monitored may include milk yield and milk conductivity. Behaviour characteristics data will be captured by the use of commercially available SmartBow™ ear tag accelerometers (from Zoetis). This data capture system will focus on real-time, directly measured information. The performance of the cow (milk yield, composition and conductivity) may be measured within a sufficiently automated milking system.

Tyndall will develop a disease specific portable diagnostic platform and use it to provide bio-chemical data from stress and disease related bio-markers. These markers are known to vary when animal well-being and welfare is compromised. Disposable multiplexed sensor cartridges will be developed specifically targeting cytokine markers including: serum amyloid A, C-reactive protein and cortisol present initially in saliva and blood, followed by milk.

Some sensors not previously validated will need to be examined against 'gold standard' measures. Cow behaviour data, e.g. feeding time and rhythms, rumination time and rhythms, activity and movement will be examined in terms of characterizing what is normal for the individual animal within the herd, how that deviates from other herd members, and how this could be an indicator of some potential problem. The milk production data and the bio-chemical data will also be sent to the cloud. This data will be integrated and prediction models developed. These models will indicate the accuracy of cow behaviour, milk yield and bio-chemical data in indicating animal illness. A degree of decision support will also be involved. For example, the cow behaviour, milk yield and bio-chemical data may all indicate a problem, but this data could be indicative of a cow in heat or with udder health issues. The conductivity data may be used to make this decision. A reactive function can also be created from data coinciding in animal illness indication. This function may take the form of an alert to the farmer/ vet of the animal requiring assistance. The data can also be interrogated for its potential to provide a descriptive function of the well-being of the cow. This can be integrated into an audit system that would act as a guarantee of animal well-being standards being met/ exceeded (to satisfy ethical requirements) and for marketing of both animal and animal products. An example of this may be that udder health of 99% of a cow herd was not compromised at any point during the lactation, which could be used for marketing purposes.

8.15.4 Expected Benefits

There are several drivers for improving the health and welfare of farm animals. But a key driver is that society is increasingly concerned about the health and welfare of farm animals from (a) an ethical viewpoint and (b) a human health viewpoint. Firstly, it is now considered important to conform to high ethical standards in animal management. Secondly, a positive health and welfare status of animals can be directly linked to a reduction in antimicrobial usage, a reduced risk of antimicrobial resistance and an overall healthier and safer environment for humans.

Expected benefits from this research will include:

- Improved dairy cow health and well-being through an early warning system, meaning early intervention during health/welfare challenges, resulting in:
    - rapid disease detection
    - potentially less animal suffering,
    - less medication, including antimicrobials,
    - less need to incur expense of vet/medication etc.,
    - more efficient use of time/less time spent on sick animals/administering medication (resulting in less stress)

- Documentation, enabled by data capture, analysis and record keeping developed in this study will allow transparency in animal health and welfare status and management on-farm. This documentation can contribute to reference systems to improve animal well-being standards on farms, e.g. this documentation could establish and meet a target that e.g. 97% of cows had no significant health or welfare issue throughout their lactation.

- Outcomes from this study using precision technologies to generate informed, real-time solutions will provide real benefits in profitability and an improved system to the farmer. It will help achieve national objectives around continuous quality assurance and better welfare standards for cattle.

8.15.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 4.3:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
Predictive Data Analytics		p	p		c		
Biomarker Sensors	c		p				
Behavioural Sensors	c		p				
DSS Animal Welfare Alerts	c	p			c/p		
Data Filtering and Processing Module		p					
Data Hub	p	c/p	p		c		
Marketplace	c	c/p	c/p		c/p		
Benchmarking report module	c				c		
KPI data export	p						
Knowledge Base - Rules and Regulations	c			c/p	c/p		

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.16 Pilot 4.4 - Optimal Chicken Farm Management

This Pilot focuses on poultry farm management, from providing guidance and support regarding bio-safety to continuous monitoring of environmental conditions, operations and animal welfare.

8.16.1 Current Scenario

Chicken farms in general do not have integrated farm management systems that can provide a holistic view of the farm activities. In many cases, partial solutions exist, enabling farmers to see raw measurements indicating the current temperature, humidity etc. using sensors provided by vendors of the farm equipment (for example Big Dutchman, Fancom, etc.). Usually, these measurements are available on-site only, thus limiting their usability. Further to that, rather frequent problems with electricity (power cuts), especially on smaller farms in rural areas, are a source of potentially huge losses for the farmers (ventilation not working, feeders not running, etc.) due to lack of notifications.

8.16.2 Envisioned Scenario

A flexible and modular solution leveraging open interfaces and standardized data formats is deployed on farms providing a holistic overview of all farm operations and just in time decision support to the farmers, from the preparation of the buildings to finishing breeding period and delivering chicken to the next stakeholder in the supply chain. A particular attention is being paid to ensuring animal wellness, including automatic wellness/stress detection based on chicken vocalization and video processing.

A range of IoT devices is used to collect data about relevant environmental parameters as well as of various activities being undertaken on the farm. The collected data is processes and analysed resulting in recommendations and advices given to farmers using a number of interaction channels. Overall, the farms will be run more efficiently resulting in increased profit and improved animal wellbeing.

The pilot will contribute towards validation of the current functionality, improvement of AI models for wellness detection as well as extension of the deployed solutions to enable their interoperability with other solutions through the use of DEMETER interfaces and data formats.

8.16.3 Approach

DNET's poultryNET platform will be used as the basis for the pilot. New IoT devices will be installed, and sensors already existing on the pilot farms will be integrated. Throughout the pilot duration, data will be collected, processed and insights generated. Deployed solution will be improved and extended using DEMETER defined APIs and data formats to enable its interaction with other relevant IT systems.

8.16.4 Expected Benefits

Production costs optimization, better product quality, and improved animal welfare.

8.16.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 4.4:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
Decision Support	c	p				p	
Data Hub		c				p	
Marketplace		c/p				c/p	

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.17 Pilot 5.1 - Disease Prediction and Supply Chain Transparency for Orchards/Vineyards

This Pilot focuses on complete farm management in vineyards/orchard for providing pest and disease management tools, thus optimizing pesticide usage and increasing crop quality. The agroNET platform will be used to provide decision support in pest and disease management and gathering information about pesticide usage, thus providing data to be incorporated into the product passport and to enable transparent supply chain.

One of the goals of the pilot is to evaluate and validate technical aspects of creating a product passport for the fruit and wine products as the basis for the creation of a transparent and trusted supply chain. In addition to the technical validation and assessment, the pilot will also address the corresponding business models and constellations. Leveraging the interoperability mechanisms provided by DEMETER, the product passport platform will gather relevant information from different farm management platforms about the supply chain activities (production, transport, retail), relying on interoperability interfaces defined by DEMETER. The pilot will investigate the required granularity of data to be collected, its lifespan, as well as technical implications of processing such potentially large amounts of data. A blockchain-based data exchange protocol (OriginTrail) will be used to ensure trust and transparency between actors in the value chain. As consumers are an important element of the supply chain and, having in mind the ever-increasing desire to know more about the food we are eating, food items will be tagged using appropriate tags (printable, combination of normal and functional ink to capture important events) to engage consumers in different settings (shops, restaurants). Consumers will be able to use DEMETER smartphone application to obtain information about the products, about their route from the time of manufacturing to the time of scanning. Information about the context of products scanning (location, time, social profile, etc.) will be shared with supply chain stakeholders who will, based on that, be able to provide additional services to consumers at the time of interaction, extend relationship with the consumers beyond the point of sale as well as to optimize production processes. Validation of the usefulness of the gathered data, the required level of detail expected by consumers, different approaches to presenting traceability information as well as potential monetization models will take place.

8.17.1 Current Scenario

Pest and disease appearance and spreading is one of the main problems in fruits/grapes production. Disease controlling is usually based on experience instead of hard facts, although there are available prediction models. However, those models provide general instructions instead of precise advises for each user. Additionally, there is a lack of evidence about the pesticides and other resources usage required by consumers willing to have an insight into whole production process and health safety of what they are eating.

8.17.2 Envisioned Scenario

A comprehensive platform providing decision support to the farmers, as well as collecting data through the whole supply chain providing relevant information to each stakeholder. IoT devices are used to collect data about environmental parameters and insects' activities. The collected data is used as inputs in prediction models resulting in advices given to farmers regarding pest and disease controlling. Improving pest and disease management, including the usage of cloud-controlled sprayers, will result in optimized and traceable pesticide usage which consequently will improve of crop quality.

The pilot will contribute towards validation of the current digitized prediction models, their improvement and adding new ones covering the main pests and diseases in various orchard/vineyards in different regions through the use of DEMETER interfaces and data formats.

8.17.3 Approach

DNET's agroNET platform will be used in the initial phase. New IoT devices will be installed and existing devices will be integrated. Throughout the pilot duration data will be collected, processed and insights generated. The deployed solution will be improved and extended using DEMETER defined APIs and data formats to enable its interaction with other relevant IT systems, like Fede's *Specialty Crops Platform* (SCP), responsible for the data exchange to and from the cloud connected sprayers in the field.

8.17.4 Expected Benefits

Pesticide usage optimization, cost decrease and increasing the fruits/grape quality. Trustworthy supply chain based on collected information from all stakeholders.

8.17.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 5.1:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	IT Services	agri-suppliers
Decision Support	c				c		
Data Hub		p	p			p	
Knowledge Base	c					p	

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.18 Pilot 5.2 - Farm of Things in Extensive Cattle Holdings

This pilot focuses on improving milk quality in dairies as well as animals' well-being and health, and how this can affect the quality and information of processed products, considering also cereals and eggs as raw materials. This pilot also considers end-user involvement in quality testing and feedback provision.

Three use cases will be developed in this project:

- UC#1: Ensuring the optimal feeding of cows by managing animal wellness and measuring crops and soil properties (irrigation, need for fertilising).
- UC#2: Improve the production management in a livestock farm integrating new technologies into the daily operations.
- UC#3: The food transparency and user involvement use case intends to integrate data brokering solutions in current production systems of dairy products and pastries.

8.18.1 Current Scenario

Pilot 5.2 identifies challenges in improving milk quality, dairies and related information according to three various sites.

According to UC#1, efforts in improving milk quality will be validated in the Kotipelto farm (http://www.kotipelto.fi/en/). Kotipelto farm is a modern private-owned dairy farm in the middle part of Finland. The farm was founded in 1781, and Marko Sorvisto is the 9th generation in the same family to run the farm. During the years, the farm has been growing in all aspects especially during the last decades.

At the moment, Kotipelto farm has a well-prepared plan to grow its milk production. Nowadays, hosting the young cattle is outsourced to the neighbour farm, and the large amount of fieldwork is done by local cultivation contractors. That way the number of milking cows is increasing to close to 200, and there are 3 milking robots in use. The feeding is totally TMR-based ration feeding, and most of the silage is stored in piles in the backyard of the barn. Kotipelto farm has co-operated with EU projects already earlier, having tested many different kinds of sensors and services.

Current technologies in production management operations (UC#2) can be observed in current production environment, in Extremadura (Spain) farms. For example, animal identification in current environments is a difficult process. Electronic Identification based on RFID is used as an official identification method used by Competent Authorities in Europe. Current RFID devices have a unique code to identify each animal which cannot be modified or deleted. Unfortunately, this unique code is the only information that can be stored in the RFID identifiers.

The current data capture in livestock is a difficult process. The farm worker finds difficulties in handling all the aspects of this common practice, trying to balance the animal testing and the hand-written notes of the animal data. This results in not very accurate or detailed information of livestock and milk quality that must be received by other actors in the supply chain such as food processing companies.

Finally (UC#3), dairy products as well as other products such as eggs and cereals are often combined in the production of processed products, with not many guarantees about the quality of these products, differences between batches, provenance information, etc. In this sense, companies with production systems that use dairy products, maintain just enough information on the quality of the products to comply with national and European regulatory systems. This use case is addressed in CODAN's facilities, a producer of processed food such as pastries, aware that society is increasingly demanding more information on the quality of products used as raw materials, and also on the manufacturing process.

8.18.2 Envisioned Scenario

Regarding the optimal feeding of cows (UC#1), the growing process described above requires a new level of precision in the awareness of status in various sectors of farming. Optimization of activities both in field work and in the cattle activities are needed. This means not only new sensor and camera solutions, but also processes that filter, pre-process and present the gathered data so, that it benefits the farmer in a maximum way.

In addition, modern farming has generated new contracting networks, where farms support each other and exploit subcontracting opportunities in various areas. This enables new highly specialized business, where service providers can focus on dedicated processes within fieldwork, harvesting and animal care. In the future, it is expected that new technologies will raise up new entrepreneurship around drones, robotics, sensor networks, etc. The management of this network of resources is becoming increasingly challenging. Not only contracting itself, but also work scheduling and delivery of data needed for the contracted work must be managed.

Moreover, the inclusion of new advanced RFID devices will assure animal traceability from farm to fork (UC#2). RFID identification is presently the safest method to guarantee the whole food chain. Advanced RFID devices bring a new level of information management. The new ISO 14223, in which these new devices are based on, will let farmers, veterinarians, markets, fairs and abattoirs to manage new information stored in these new transponders.

The capability to save, store, change, update and delete specific information associated to every animal, makes the electronic reader a very useful management tool and surely, a very interesting device to be acquired. Sensitive information regarding animal health will be protected from manipulation or deletion.

The information written by all these actors in the supply chain can be monitored and offered to the final consumer.

With sanitary purposes, the introduction of voice recognition technologies in the data capture process will let the farmer handle the animal freely and register the animal data through his/her voice.

The food transparency and user involvement use case (UC#3) intends to integrate data brokering solutions in current production systems of dairy products and pastries, with the purpose of tracking ingredients and final products. The company engaged in manufacturing, which participates in this project, has beaten in 2017 its turnover record in the sale of pastries, after reaching €28.4 million. These data can be indicative of the number of users interested in the benefits of optimizing production systems.

8.18.3 Approach

The Kotipelto farm will be present in the UC#1, which will be supported by an extensive platform, where a customizable GUI will be provided both for the farmer and the contractor network as well as tools for managing the work. The aim is to provide a refined and smart view to the farm data, having the main emphasis in the easy use and applicability of multitude of heterogeneous data sources. New sensor and surveillance systems will be developed based on the farmer needs.

Regarding animal identification (UC#2), the goal is to introduce in this pilot -and in the market- advanced animal identification devices under ISO 14223, 1-3 standards. As manufacturers are not developing commercial devices yet, since the approval of ISO 14223 regulation is very recent and the number and characteristics of the data fields in the transponders are yet under discussion, we will base our work on prototypes first.

The line of attack of this pilot regarding data capture is initially testing the technology, so new software on smart glasses and a smart watch will be developed. If the results are good enough, the development will be extended to more fields in data capture.

Regarding the provision of food transparency (UC#3), the producers' platform will be extended to support information generated in the previous steps in the pilot's value chain, allowing the generation of a new batch of products with better labelling, that will be provided to a retail facility to complete the supply chain.

Regarding the provision of techniques to involve end users in the production of food, consumer workshops will be organized in Codan Park (Madrid, Spain), where the process of elaboration and processing of products will be explained, and an initial interaction of these groups will be provided.

8.18.4 Expected Benefits

- Production costs optimization, better product quality, improved animal welfare and better farm work organisation (UC#1).
- Reliability of the animal identification and livestock's management as a tool of traceability, animal welfare and food security (UC#2).
- Electronic identification as a revolution in the livestock sector, which will allow the agri-food sector to go beyond the current barriers that technology has now (UC#2).
- Increase of end-user involvement for the proposal or improvements of recipes, quality of ingredients and social awareness (UC#3).
- Improvement of production platform with extended product information and provision of new production batch to test information transmission along the supply chain (UC#3).

8.18.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 5.2:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	General Public	agri-suppliers
Farming Process Optimisation	p						c
Milk Yield and Quality							c
work optimization	p						c
meat & calf yield and quality							c
machinery use optimization							p

Stakeholders and interests for pilot 5.2 – continued:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	General Public	agri-suppliers
animal welfare and regulations					p		
increase consumer interest					p	c	
farmer benefit and success					p		
Information Quality							c
information on product quality							p

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.19 Pilot 5.3 - Pollination Optimisation in Apiculture

Bees are among the most economically valuable pollinators of crop monocultures in the world and play a key role in improving the profitability of many crops. Studies on the importance of pollinators on crops that are directly consumed by humans show that three out of four crops depend, at least in part, on pollinators. Pollinators are essential for 13 crops, production is highly pollinator dependent for 30, moderately for 27 and slightly for 21 crops. Honeybees, mainly Apis mellifera, remain the most economically valuable pollinators of crop monocultures worldwide and yields of some fruit, seed and nut crops decrease by more than 90% without these pollinators (Klein, 2007). Pollination is the highest agriculture contributor to yields worldwide, contributing far beyond any other management practice (Why bees matter, FAO, 2018).

This pilot will address apiary management and provide the technology and methods to optimize the pollination by honey bees. It will connect different agriculture systems, in particular farm management systems and apiary monitoring systems with advisory and decision support systems to enable better communication of farmers and beekeepers to protect bees and to optimise pollination of crops with the aim of improving yields. Data analytics modules will reason over acquired data e.g. satellite data can be used to process data about local crop types and phenological status; and exchange relevant data on activities like pesticide sprays and hive location etc. to provide suitable advices to farmers and beekeepers for more informed decisions. The pilot will involve three beekeepers and three farmers for the testing and validation, and will be trialled and validated on arable crops.

8.19.1 As is Scenario

According to a Kleffmann Group study commissioned by the Polish Plant Protection Association in 2016, about 74% of beekeepers declare cooperation with farmers, which usually consists in placing hives at plantations (97%), using plant protection products which are as safe as possible for bees (84%) and informing beekeepers about the dates of plant protection interventions (81%). However, the communication between beekeepers and farmers in Poland is mostly done informally (e.g. by phone), not monitored and not supported by any system. It leads to the accidental poisoning of bees. For example, in May 2018, a well-known beekeeper from Wejherowo, a city in northern Poland, took his bees to the rapeseed field. Inadvertently, the field where the insects collected nectar was sprayed with an insecticidal plant protection product during the day (this must not be done during the day because of the insects). After this event, bees from more than 100 beehives from surrounding villages were poisoned.

On the farmers side, studies from 2017 show that only 40% of Polish farmers tried some farm management systems, but 70% of farmers surveyed intend to use farm management support programmes in the future. The two main factors responsible for the lack of use of specialized software by farmers include: fear that the costs of purchasing equipment and software will not be reimbursed during the period of its use and problems related to the operation of computer equipment and the software itself. This year WODR and PSNC, with several other partners, started a project aiming at building a national IT system for plant protection - eDWIN.

The typical “as is scenario” story is as follows:

- Beekeeper Jan runs a medium-sized mobile apiary in Wielkopolska (about 40 hives). He collaborates with a farmer Michał, and transport his hives to Michał’s fields for pollination. They usually contact by phone to set the date for the transport of hives and inform about planned sprayings. Recently Jan bought several sabotage sensors with a GPS locator for his hives to protect against theft, provided by ControlBee. The system shows him the location of his hives and sends out notifications when a change in the location of the hive is detected. Now, he plans to buy more hive sensors e.g. weight to be able to check the amount of honey in the hives remotely.
- Farmer Michał runs a medium-sized farm in Wielkopolska and collaborates with the beekeeper Jan to pollinate his crops by bees. Michał make notes about his fields, crops and plant protection treatments (by hand or in an excel file), but is not using any farm management software at the moment, because of its high cost. He uses an app to communicate with his advisor and receive notifications from regional advisory centre (WODR). Recently, he started to test the farm management system that is being developed by WODR.

The apiary management system used by Jan, the farm management system used by Michał and the advisory services are not integrated in any way and cannot transfer data to each other.

8.19.2 Envisioned Scenario

The following challenges in pollination that are being addressed in the pilot:

- Lack of detailed information of field saturation with pollinators: In Poland in 2009, the number of bee colonies was enough for pollination to a minimum degree of about 44% of the area of the main cultivated plants, flowering at a similar time and needs for pollination increase [Majewski, 2011].
- Lack of food diversity for bees: In summer, they have plenty of it in the form of agricultural crops: rape, buckwheat, raspberry or fruit orchards, but they do not like monotony. They need food that is a mixture of pollen and nectars of different plants, in enough quantity, all year round. Bees are also harmed by the cultivation of only one plant species over a large area, as insects do not have access to a wide variety of benefits. [PSOR, 2019]

- Lack of integrated control on pollination: Land-use change, intensive agricultural management and pesticide use are among the main threats to pollinators as listed by the first global report on pollinators issued by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

The envisioned future scenario story in the pilot is the following:

- Beekeeper Jan runs a medium-sized mobile apiary in Wielkopolska (about 40 hives). The beekeeper uses an apiary management system (ControlBee in the pilot), which is integrated with DEMETER interoperability space mechanisms with a pollination optimisation service.
- Jan choses the apiary management system because it can use sensors to protect his hives against theft and to remotely monitor hive conditions in his mobile apiary, e.g. the temperature and the amount of honey produced. The technical equipment installed in his apiary sends information to the apiary management system, including the current geographical position of the apiary.

- Jan connects to the pollination optimization service (developed in DEMETER) and turns on the notification and warning functions. Now the apiary management system displays the area in which his hives are located. Jan can also display a map of fields where he can place his apiary with crops producing nectar. He will also receive different types of warnings e.g. about planned spraying in an area of up to 5 km.
- The farmer Michał uses farm management system (eDWIN in the pilot), which is integrated system to plan and record his farm activities e.g. to construct the seeding plan or to introduce planned spraying on his crops.
- As a bee-friendly farmer he connects to a pollination optimisation service. Next, he indicates those fields and crops which will be safe and attractive for bees. As a result, he is informed about the number of hives registered near his crops and if the number of hives is enough to pollinate his crops. He can use the system to invite beekeepers to his fields. He receives information if a beekeeper is interested in putting hives on a field and they can get in contact with each other.
- When adding information about planned spraying, the farmer is warned if there are hives registered nearby and gets reminders about best practices in conducting plant protection treatment. The system also sends a notification about the spraying to the beekeepers who have registered hives nearby.
- Jan receives notification of planned spraying. He can see the details of the spraying and is also able to contact the farmer to discuss details is needed. Thanks to this if needed he can protect hives or prepare to move his apiary to a safe place for bees and establish a new location for his apiary on the basis of the information contained in the apiary management system.

Using DEMETER enhancing services will enable easy integration of the apiary management system with multiple, potentially different farm management systems registered at the DEMETER Hub. We believe DEMETER will also enable the apiary management system to easily consume in future data from other services and data sources (e.g. EO public weather data, NDVI) to provide more added value services to the beekeepers (e.g. notification of the start of flowering of plants).

8.19.3 Approach

The pilot will develop and provide service for the pollination optimization. The service will connect farm management system with apiary managements system with advisory and decision support services. The goal of the integration of different agriculture systems will is to enable a better communication of farmers and beekeepers, to protect bees and to optimise pollination of crops with the aim of improving their yields.

In particular, the pilot will connect the farm management system (eDWIN Virtual Farm) created by the regional agriculture advisory centre (WODR) and apiary management systems (provided by ControlBee) and DEMETER DSS services to manage beekeeping information, including apiaries and farming activities like planned fertilizations (based on the information from farmers), and to provide new advisory services.

Existing systems will be improved with new functionality, enabling the collaboration scenario without the need of using new system. Moreover, existing sensors will be improved and new apiary sensors will be developed to allow remote monitoring of mobile apiaries.

8.19.4 Expected Benefits

Expected benefits include:

- better communication between farmers and beekeepers,
- better control and management of pollinators,
- better spraying control and bee protection,
- increasing yields and quality,
- monitoring and management of saturation of fields with bees,
- better gains for beekeepers.

8.19.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p).

The following table provides an overview of the identified stakeholders and interests for pilot 5.3:

Interests	Stakeholders						
	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	General Public	IT Services
Hive sensors	c		p				
Hive Health Model		p					p
Hive Management Software	c	p					
Pollination Service Matching	c				p		
Pesticide Alerts	c				p		
Data Hub		p					p
Knowledge Base - promote sustainable bee keeping	c				p	c	
Knowledge Base - Promote pollination benefits	c				p	c	
Marketplace	c	p	p		p		p

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

8.20 Pilot 5.4 - Transparent Supply Chain in Poultry Industry

This pilot focuses on the supply part of the poultry industry, providing information sharing about animal wellbeing and resources used during the production, thus creating a basis for a transparent supply chain.

The goals are to evaluate and validate technical aspects of creating a product passport for poultry products as the basis for creation of a transparent and trusted supply chain. In addition to the technical validation and assessment, this pilot will also address the corresponding business models and constellations. Leveraging the interoperability mechanisms provided by DEMETER, the product passport platform will gather relevant information from different farm management platforms about the supply chain activities (production, transport, retail), relying on interoperability interfaces defined by DEMETER. The pilot will investigate the required granularity of data to be collected, its lifespan, as well as technical implications of processing such potentially large amounts of data. A blockchain-based data exchange protocol (OriginTrail) will be used to ensure trust and transparency between actors in the value chain. As consumers are an important element of the supply chain and, having in mind the ever-increasing desire to know more about the food we are eating, food items will be tagged using appropriate tags (printable, combination of normal and functional ink to capture important events) to engage consumers in different settings (shops, restaurants). Consumers will be able to use the DEMETER smartphone application to obtain information about the products, about their route from the time of manufacturing to the time of scanning. Information about the context of products scanning (location, time, social profile, etc.) will be shared with supply chain stakeholders who will, based on that, be able to provide additional services to consumers at the time of interaction, extend the relationship with consumers beyond the point of sale as well as to optimize production processes.

Validation of the usefulness of the gathered data, the required level of detail expected by consumers, different approaches to presenting traceability information as well as potential monetization models will be done.

8.20.1 Current Scenario

Supply chain in poultry industry is well developed with several stakeholders involved. However, there is a lack of information about chicken wellbeing, medical treatment, feeding patterns, etc. required by stakeholders, especially consumers. Even if some of that information exists, they are isolated without an integrated overview of the complete supply chain, from breeding process to retail and consumers.

8.20.2 Envisioned Scenario

Providing a transparent and trustworthy insight into the whole meat production process including information from all involved stakeholders is the main challenge. Information about each step of chicken, production, from feed intake, medical treatments, conditions provided during the production, used resources, feed origin etc. to transporting to the slaughter house and after to the consumers will be collected and recorded enabling a transparent supply chain.

8.20.3 Approach

DNET's poultryNET platform will be used for gathering data from the breeding process perspective, including the amount of feed. Inputs and feedback from the farmer will be used to improve and validate the functionality. The outputs of poultryNET will be combined with information provided by fleet management systems of transport companies delivering the feed and transporting chicken. All information will be summarized and stored in the Product passport and forwarded to a distributed ledger using OriginTrail protocol.

8.20.4 Expected Benefits

Increased transparency of the complete supply chain, providing trustworthy information to consumers about the production process.

8.20.5 Stakeholders

To achieve the objectives of the pilot, a number of key stakeholder interests have been identified. The currently identified internal and external participants in the DEMETER Pilots have been consolidated into generic stakeholder classes. The role of a stakeholder can be a consumer (c), provider (p) or combined consumer/provider (c/p). The following table provides an overview of the identified stakeholders and interests for pilot 5.4:

	Stakeholders						
Interests	Farmer	SW provider	HW provider	Public Authorities	Advisory Service	General Public	IT Services
Decision Support	c				c		
Data Hub	c	p					p
Knowledge Base		p					p

The specific workflow diagram and specifications of used data and components will be provided in D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (July 2020).

9 Next Steps

The pilot focus at this stage lies on the planning and execution of the Pilot Round 1, where initial results will be rolled out to try and test DEMETER concepts and components. The deliverable *D5.3 Testbed, deployment, system extensions and applications for pilot round 1,* which will be published in July 2020, will describe in detail the pilot setup and system deployment at pilot sites. It describes the specific use cases, all systems extensions, applications and data to be used, and outlines the implementation plans.

The refined understanding of the DEMETER pilots, their stakeholders and requirements is used to guide all subsequent DEMETER activities. The following Annexes contain information on used software, hardware, available data, preferred standards, etc. These collections have been compiled based on standardised templets developed in cooperation with all other DEMETER WPs. Abstracting the input documented in this report, and especially in the following Annexes, into architectural concerns, concepts and DEMETER components, is carried out in the WPs 2, 3 and 4 and documented in their respective deliverables. In due course, the information presented in the Annexes, for lack of a more suitable project deliverable at the project start, will be moved to the deliverable reports where they have a close native fit.

In parallel, close cooperation with WP6 and WP7 will narrow down work on the next and final iteration of this this report, to support MAA dissemination and community building activities, specifically targeted at the identified stakeholders and their requirements.

Based on the results of these activities, the final Report on Stakeholder Requirements, Pilots Design, and Specification will become available in April 2021, with an emphasize on further refining the identification of the stakeholders, their non-technical requirements, and how these can be sustainably addressed by DEMETER.

10 Annex A - Identified Relevant Standards

This section contains an overview of standards that have been identified by the pilots and other WPs as relevant to DEMETER. The mapping to the pilots only states where a standards requirement was raised, not where it will be addressed or used. The objective is to provide other WPs with an overview of known standards to be taken into consideration. If no pilot is mapped to a named standard, it has been suggested by a WP. The WP 6 *Task 6.5 Standardisation Framework* is dedicated to support the uptake, use, and adaptation of standards in DEMETER and to establish liaison activities with relevant standards organisations. The initial results and plans will become available in the DEMETER Deliverable *D6.5 Intermediate communication, dissemination and standardisation activities report* in February 2021.

10.1 Internet Interoperability Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
ISO/IEC AWI 21823													x		x			x		
ISO/IEC 29182													x		x			x		
AIOTI WG03	X												x		x			x		
FIWARE not spec.									x	x				x						
FIWARE - NGSI	X	x								x			x	x		x				
W3C not spec.							x				x									
ETSI NGSI-LD	x								x	x		x								

10.2 Communication Infrastructure Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
LTE	x									x									x	
Wi-Fi	x									x								x		X
RFID																		x		
IEEE 802.15.4	x																	x		

10.3 Communication Protocol Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
OASIS - MQTT	x	x								x							x	x	x	
NB-IoT	x									x							x			
LoRa	x																x	x	x	x
ISO 11783 - ISOBUS	x					x			x	x							x	x		
AEF: EFDI												x								
ISO 18000 (RFID)																		x		
SigFoX	x																			

European Union
European Regional
Development Fund

10.4 Geospatial Interoperability Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
OGC WFS									x	x		x								
OGC WMS	x								x	x		x								
OGC WCS									x	x		x								
OGC WPS									x	x		x								
OGC Agriculture									x	x		x								
OGC SWE																				
OGC POI									x	x		x								

10.5 Environmental and Animal Welfare Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
ISO 14223 1-3																		x		
ISO 21622	x	x																		
ISO 21622-3			x																	
ICAR (ISO 11784 & 11785)																				
Welfare Quality® Assessment protocol for cattle															x					

10.6 Consumer / Food Chain Transparency / Retail Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
IFS 2002																		x		
GS1 EPCIS													x			x	x			x
GS1 CBV																	x			x

10.7 Blockchain Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
ERC725																	x			x
ERC20																	x			x

10.8 Cloud Computing Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
ISO/IEC 19941:2017													x		x			x		
ISO/IEC 19944:2017													x		x			x		

10.9 AI, Machine Learning and Modelling Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
ISO/IEC AWI 23053													x		x			x		

10.10 Vocabularies, Ontologies, Data Exchange Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
FOODIE ontology	x						x	x											x	
FAO AGROVOC								x										x		
ISO/IEC 2382													x		x			x		
AgroXML/AgroRDF										x		x								
Nordic Cattle Data Exchange																		x		
Open Data Publication	x										x									
ISO 11783 – ADAPT (Data exchange standard for FMIS)										x										
ETSI TS 103 410-6 (SAREF4AGRI) (Agricultural IoT devices standard)	x																			
ISOBUS (Farm machinery domain)										x										
NGSIv2 (Context information for sensors and other IoT devices)	x													x						
ETSI NGSI-LD	x													x				x		
ICAR (Livestock domain)																				
GS1-EPCIS (Supply chain domain)																	x			x
SSN / SOSA Ontology							x	x												

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
OGC (Earth Observation domain)																				
AFarCloud ontology and data exchange models																		x		
GS1 CBV																	x			x
SAREF (SAREF4Agri)																				
ISO 19111-2	x	x																		
ISO 21622	x	x																		
RDF data cube vocabulary with QB4ST extension							x	x												

10.11 Security Standards

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
SAML																				
XACML	x																x			x
TLS														x						
DTLS	x																x			x
Privacy-ABC	x																x			x
Capability Authorization	x																x			x
OpenID	x																x			x

	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
Oauth2	x													x						
WS-Federation																				
WS-Trust																				
XML-encryption																				
SHA																				
XML-signature																				
DLT																				
CAS																				

11 Annex B - Used Applications

This section contains a list of applications to be used in DEMETER and maps them to the pilots. The mapping to the pilots only states where the use of the applications was indicated. The objective is to provide other WPs with an overview of existing applications to be taken into consideration. Which applications, hardware, system extensions, data and DEMETER components will be used in the pilot round 1, will be documented in D5.3 Testbed, deployment, system extensions and applications for pilot round 1, which will become available in August 2020.

Applications	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
Mega Coordinator	x	x																		
Smart Agriculture	x	x																		
Smart Irrigation Service for Rice			x																	
Smart Irrigation Service for Maize			x																	
Fertilisation Advisory Service for Rice & Maize			x																	
INOVAGRIA				x																
EPSU								x											x	
eDWIN								x												
SensLog							x													
HSlayers NG							x													
Micka							x													
Layman							x													
AVR Connect												x								
WatchItGrow												x								
Decision Support System														x						

Applications	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
Traceability System														x						
Automated Agricultural Process Documentation Engine						x														
Automated Agricultural Process Documentation Staging System					x															
Agricolus FMIS									x											
Agricolus Water Decision Support System									x											
Agricolus Nutrient Decision Support System									x											
Agricolus Olive Fruit Fly Decision Support System									x											
Zoetis Data visualization															x					
Lely management system															x					
Tyndall Bespoke Analog Front End															x					
poultryNET																x				x
Agronet																	x			
OriginTrail Decentralized Network																	x			x
Network Operating System (nOS)																	x			x
Product passport																	x			x

Applications	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
TagItWine																	x			
Feedback APP																		x		
AFARCloud Middleware																		x		
ControlBee																			x	
siloNET																				x
AgIoT										x										
AgRob Vxx										x										

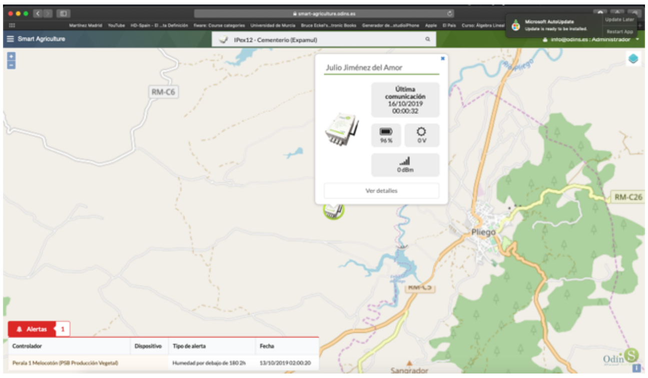
11.1 Mega Coordinator

The mega coordinator manages the different connections between all the management irrigation systems and all irrigation control systems that implements the ISO 21622.

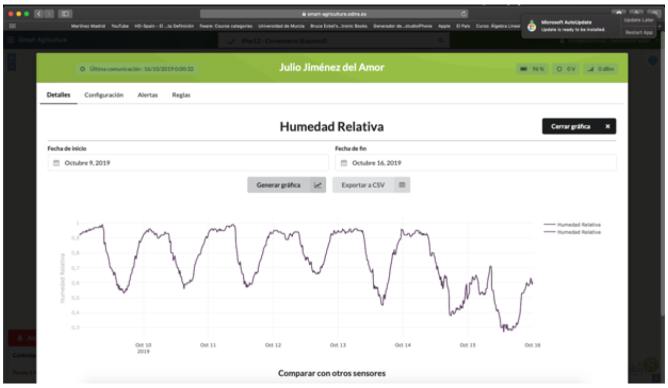
It is formed by different web services (SOAP and REST), which correspond to the operations defined in the ISO 21622 standard and a web interface, where the possible connections and security can be managed.

ID		SC-Tragsa-1
Responsible partner		Tragsa
Component name		Mega Coordinator
Functionalities offered		Data analysis User interface Visualisation GIS Routing Scheduling Security Permissions
Data input	Description	It can receive requests from the different management software and the responses of the control software to the requests made.
	Format	XML, JSON
	Standard adopted	SOAP, REST, NGSI
Data output	Description	It can send requests to the different control software and the responses of the management software to the requests received before.
	Format	XML, JSON
	Standard adopted	SOAP, REST, NGSI
Integration requirements		ISO 21622

11.2 Smart Agriculture



Smart Agriculture is a web-based platform based on standards and open protocols (i.e. NGSI, NGSI-LD, MQTT, CoAP). It comprises specific modules for the integration of IoT devices, basic data exploitation and map-based interface. The adoption of standards and open protocols makes it easy to integrate IoT devices, which comply with these standards. Additionally, exchanging information in both directions (from and towards) a third-party platform is also possible thanks to a north-bound API based on NGSI, NGSI-LD.



This platform allows for customized rules for triggering alarms and actuations depending on the measurements provided by sensors or weather stations. Reports and graphs are also provided thanks to a nice web-based interface.

GIS integration is made thanks to the WMS and WFS technology, so that SigPac (Spanish *Geographic Information System for Agricultural Parcels*) information regarding crops can be obtained. Such integration makes also possible to integrate other geo-localized information such as satellite images, or even drone images.

ID		SC-OdinS-1
Responsible partner		Odin Solutions
Component name		Smart Agriculture
Functionalities offered		Data analysis User interface NGSI API NGSI-LD API Basic Data analytics Visualisation SigPac integration Sentinel GIS Irrigation management Scheduling Irrigation and alert rules definition Alert Notification via Push notification thanks to the OdinS Monitor App (iOS and Android)
Data input	Description	Sensor data from the field (temperature, humidity, conductivity) Sensor data from weather station Water counters Hydrants status
	Format	JSON
	Standard adopted	MQTT
Data output	Description	NGSI, NGSI-LD
	Format	JSON, JSON-LD
	Standard adopted	NGSIv2 and NGSI-LD
Integration requirements		NGSI, NGSI-LD

11.3 Smart Irrigation Service for Rice

The Smart Irrigation Service for Rice (SIS-Rice) enables the automated control of water height in rice fields throughout the cultivation period. The service is based on real-time salinity and water height measurements collected via a custom sensor (SmartPaddy), which is deployed within each rice paddy. Based on these measurements and an expert-based model, SIS-Rice can control electric input valves for irrigation and water output valves for drainage, minimising the water use during the season. In addition to the automated workflow, the end-users can directly control the sensor by sending messages to overtake actions over the robotic management. In the case of the individual farmers with no automatic valves system install, SIS-Rice can provide the necessary information so that the farmer can manually control the water height on his/her field.

ID		AC-ELGO-1
Responsible partner		ELGO
Component name		Smart Irrigation Service for Rice
Functionalities offered		Determination of rice fields' flooding needs based on SmartPaddy sensor measurements Automatic control of input/output electric valves in rice paddies Provision of relevant notifications to users
Data input	Description	Salinity and water height measurements from SmartPaddy sensors
	Format	CSV
	Standard adopted	None
Data output	Description	Structured SMS messages to electrical valves SMS notifications to users
	Format	SMS
	Standard adopted	GSM
Integration requirements		Parser of CSV input; structured SMS creation

11.4 Smart Irrigation Service for Maize

The Smart Irrigation Service for Maize (SIS-Maize) provides support for irrigation of maize crops throughout the cultivation period. It employs machine learning techniques for modelling the crop's irrigation requirements, based on appropriate indices calculated from UAV-collected thermal and multispectral imagery. The service produces irrigation needs maps for each field, with possibly different homogeneous subregions defined for each field. SIS-Maize allows the farmer to minimise water use, maintaining yield at the same time.

ID		AC-ELGO-2
Responsible partner		ELGO
Component name		Smart Irrigation Service for Maize
Functionalities offered		Estimation of maize fields' irrigation based on UAV-collected imagery Visualisation of irrigation prescription maps Provision of relevant notifications to users
Data input	Description	Thermal and multispectral imagery collected from UAVs
	Format	Sensor-specific; typically, GeoTIFF
	Standard adopted	GeoTIFF

Data output	Description	Irrigation prescription maps SMS notifications to users
	Format	geojson (or any other format needed)
	Standard adopted	GeoJSON specification
Integration requirements		Support for georeferenced vector file readining; structured SMS creation; Pix4Dmapper Pro if ortho-mosaicking processing is required to be performed on the server side

11.5 Fertilisation Advisory Service for Rice & Maize

The Fertilisation Advisory Service for Rice & Maize (FertiRM) provides prescription maps for nitrogen fertilisation in rice and maize crops. The analysis is based on UAV-collected (or satellite-collected if very high-resolution imagery is available) multispectral imagery, acquired at key stages of the cultivation's growth circle. Advanced machine learning techniques are employed for identifying nitrogen-stressed sub-regions within each field. The service provides spatially variable nitrogen prescription maps, in order to support variable rate application (VRA) techniques with specialised spreaders,

ID		AC-ELGO-3
Responsible partner		ELGO
Component name		Fertilisation Advisory Service for Rice & Maize
Functionalities offered		Estimation of rice or maize fields' nitrogen needs based on UAV-collected imagery Visualisation of irrigation prescription maps Provision of relevant notifications to users
Data input	Description	Multispectral imagery collected from UAVs of very high-resolution satellite sensors
	Format	Raster
	Standard adopted	GeoTIFF
Data output	Description	Fertilisation prescription maps SMS notifications to users
	Format	geojson (or any other format needed)
	Standard adopted	GeoJSON specification
Integration requirements		Support for georeferenced vector file reading; structured SMS creation; Pix4Dmapper Pro if ortho-mosaicking processing is required to be performed on the server side

11.6 Inovagria Farm Management Platform

INOVAGRIA is a Smart Farming Managing Software Platform designed to improve farming activities regardless of size. Main components of the application are:

- Weather Forecast Module – provides meteorological data and decision support for farming activities;
- Subsidies Management Module – provides guidance in the process of documentation preparation for agricultural subsidies;

- Land Contract Lease Management Module – simplifies the land lease management processes and provides decision support for payments;
- Agricultural Works Module – field work management, simulation and planning;
- GIS Module – management of the farms geographical data;
- Animal Registry Module – farm animal management;
- Fertilization Decision Support Module – provides real time monitoring and historical data, alerts and notifications. Identifies fertility needs and provides intelligent fertility decision support;
- Irrigation Decision Support Module - provides real time monitoring and historical data, alerts and notifications. Identifies irrigation needs and provides intelligent irrigation decision support.

Project Web Site: https://www.inovagria.ro/

ID		AC-SIV-INOVAGRIA
Responsible partner		SIVECO Romania S.A.
Component name		Inovagria Farm Management Platform
Functionalities offered		User interface GIS Management, Analysis and Visualization Data Management, Analysis and Processing Data Imports and Exports Decision Support
Data input	Description	Production data Local Soil moisture sensors data Local Soil temperature sensors data Local Air Temperature sensors data Local Air moisture Sensors data Local real time weather service channel data Electrochemical sensors (pH and soil nutrient levels) Local Rain Sensors Farm data: Land use / Irrigated Area / Crop Type, Water availability, slope/drainage, Pesticides, Fertilization, Yield, Site Inspection Data Regional Data (NUTS 1-3, Public Soil Maps, etc) Multi-date Remote Sensing Imagery Imagery Data APPR Excel Data – historical research data for corn crops
	Format	XML, WMS, ESRI Shapefile, XLSX, CSV, TXT
	Standard adopted	OGC WMS, WMCS, WFS
Data output	Description	Reporting Data, Result Data, Decision Data
	Format	XML, XLSX, ESRI Shapefile, JPG, PNG, CSV, WKT
	Standard adopted	OGC WMS, WMCS, WFS
Integration requirements		FMS, Other DEMETER component, APIs, etc.

11.7 EPSU

Electronic Platform of Services (EPSU): software enabling communication of WODR (advisors) with farmers and residents of rural areas. The service enables the provision of services in the field of agriculture in Wielkopolska region electronically using the public telecommunications network, implementing different e-services. Access to EPSU is provided by web interface and mobile application.

EPSU offers a back-office solution called eWODR - a system, developed by WODR. eWODR contains a lot of databases of farmers, advisors, meteo data, functionalities and also internal WODR services.

ID		AC-WODR-1
Responsible partner		WODR
Component name		EPSU
Functionalities offered		Functionalities offered include: - contact farmers with the nearest advisor - the possibility to ask a question via the Internet, which will be sent to the best specialist in a given field - the possibility of receiving information prepared by WODR from the fields of interest to you - meteorological information from agro-meteorological stations working in the network created by the Wielkopolska Agricultural Advisory Centre in Poznań and the Institute of Plant Protection - National Research Institute - Decision support system for plant protection and other functions. Interfaces: Web and mobile user interface (front-office for farmers), Advisors back-office, API for meteo data, API for Decision Support Systems in Plant Protection.
Data input	Description	- location of farm - questions to advisors - user’s profile - meteorological data
	Format	TERYT code of the location, text (questionnaire form)
	Standard adopted	REST
Data output	Description	- advisor contact information - advice, answers from advisors/dss - meteo data (incl. Temperature, humidity, wind) - DSS models results, - alerts and alarms,
	Format	JSON

	Standard adopted	REST, GeoJSON
Integration requirements		FADN database, FMS

11.8 eDWIN

eDWIN is a project, that will develop a national IT system for plant protection and will be a work tool for farmers and food consumers. Data provided under the system will also be used by public institutions, and scientific units, to carry out their own tasks in the field of plant protection. The system will be used to provide e-services by the Agricultural Advisory Centers.

The project is implemented in a partnership consisting of a total of 19 units, and the leading partner is the Wielkopolska Agricultural Advisory Center in Poznań.

The Online Consulting and Decision Support Platform in Integrated Plant Protection (eDWIN) will be based on the existing in the WODR, the Electronic Platform for the Provision of Services (EPSU). Agricultural Advisory The system will be centralized, it will enable integration local solutions (16 Advisory Centers - taking into account the characteristics of individual voivodships).

An important element of the project is the comprehensive use of existing databases currently located in distributed and autonomous systems of various institutions. Gathering many local data sources in one system will be the optimal solution affecting interdisciplinarity, credibility and certainty of information shared by eDWIN in the future.

The project also envisages the construction of a national network of agrometeorological stations - field meteorological stations located in agricultural areas equipped with specialized equipment. In the whole system, it is very important to receive real-time local information about occurring meteorological phenomena.

ID		AC-WODR-PSNC-1
Responsible partner		WODR, PSNC
Component name		eDWIN - a national farm management IT system for plant protection
Functionalities offered		Farm management system (in development) offering functionalities of managing fields (including agrotechnical operations), decision support system, plant protection models (pest predictions), contact between farmer and advisors
Data input	Description	External information systems (lists of plants, pesticides, pests), meteo data, gis, forecast predictions data, farm data
	Format	JSON, others
	Standard adopted	REST, GeoJSON
Data output	Description	Model predictions, proposed decisions, alerts and alarms, processed farm data
	Format	JSON, others

	Standard adopted	REST, GeoJSON
Integration requirements		HTTPS/REST API, IdP

11.9 SensLog

SensLog is web-based sensor data management application. This component provides functionality for receiving, storing, pre-processing and publishing of sensor data. SensLog is suitable for numeric or textual sensor data from static in-situ or mobile sensors and is also suitable for storing Volunteered geographic information (VGI) with connected multimedia files.

SensLog stores sensor data in own data model implemented in RDBMS with spatial extension. Data model is based on ISO Observations&Measurements standard but it is extended by alerts, group management, and improved by mechanism of partitioning. Data model is designed as extensible from very beginning.

SensLog is modular and scalable solution and it consists of several modules. SensLog provides RESTful API with JSON data encoding for most of modules and OGC SOS core services for publishing of stored data. SensLog interface is extended by system of Connectors that are transforming API of data producers where we are not able to influence that to standard SensLog API.

SensLog can be deployed in web application container (Apache Tomcat) or using Docker container.

ID		Lesprojekt
Responsible partner		Lesprojekt
Component name		SensLog
Functionalities offered		Data management, Data analysis, Data publishing User interface
Data input	Description	Sensor data from tractor Sensor data from static sensors
	Format	JSON
	Standard adopted	None
Data output	Description	Sensor data from tractor Sensor data from static sensors
	Format	JSON
	Standard adopted	OGC SOS
Integration requirements		Java 8, Apache Tomcat, Docker

11.10 HSlayers NG

Hlayers NG (https://ng.hslayers.org/) is a web mapping library written in JavaScript. It extends OpenLayers 4 functionality and takes basic ideas from the previous HSlayers library, but uses modern JS frameworks instead of ExtSJS 3 at the frontend and provides better adaptability. That's why the NG

("Next Generation") is added to its name. It is still under development and provided as open source. HSLayers is built in a modular way which enables the modules to be freely attached and removed as far as the dependencies for each of them are satisfied. The dependency checking is done automatically.

The core of the framework is developed using AngularJS, requireJS and Bootstrap. This combination of frameworks was chosen mainly for providing fast and scalable development and for providing modern responsive layout of application.

The most important modules are:

- Map: The map functionality is provided by OpenLayers4 and extended by some controls like navigation bar, scale line, attribution dialog, GPS and compass tracking etc. It supports multi-touch gestures, but the performance is highly dependent on the browser and mobile device hardware.
- Layer manager and legend: Layer manager is used for listing all the map layers, displaying or hiding them and setting the transparency. The user can view layers metadata and attribution by clicking on it. A legend is fetched from the server and displayed in a separate panel for all the WMS layers on the map. Grouping of layers in containers is also provided which enables a more user friendly and organized representation of layers.
- OGC Web Services parser: This is used for GetCapabilities requests to different map servers and parsing the response. It can then be used for automatic or user initiated generation of map layers only by knowing the URL to the specific OGC standardized map service.
- Linked Open Data explorer: Eurostat explorer is a demo application (module) which queries Semantic Web data sources via SPARQL endpoints. It demonstrates the feasibility of automatic query building for Eurostat report data and displaying it on a map of NUTS2 regions (specified in GeoJSON file) according to the calculated transparency ratios. On the server side it uses a Virtuoso Universal Server which is a middleware and database engine hybrid that combines the functionality of a traditional RDBMS, ORDBMS, virtual database, RDF, XML, free-text, web application server and file server functionality in a single system.

ID		Lesprojekt
Responsible partner		Lesprojekt
Component name		HSlayers NG
Functionalities offered		Data visualisation in 2D and 3D Data analysis
Data input	Description	Any geospatial data
	Format	WMS, WFS, KML, WCS, RDF….
	Standard adopted	OGC visualisation standards
Data output	Description	…
	Format	WMS, WFS, WCS, KML, GeoJSON
	Standard adopted	WMS, WFS, WCS, KML, GeoJSON
Integration requirements		API

11.11 Micka

(Open)Micka is a Web application for management and discovery of (geo)spatial (meta)data. From a user perspective, it represents a cataloguing tool for searching and finding relevant resources, such as geospatial and non-geospatial datasets, Web services, sensor measurements, map compositions, (traffic) models, documents, Web pages, reports, legislation or e-shop. The main goal of (Open)Micka is to connect all the relevant kinds of resources and provide answers, for instance, to the following questions:

- show me all data and (map) visualizations that were developed according to such legislation or
- show me what has been done with such sensor measurements (derived datasets, policy, link to e-shop selling the raw sensor measurements…).

As such, (Open)Micka is intended to be used as a tool for discovery of various kinds of resources. (Open)Micka is a customizable and scalable tool that is going to be modified according to the purposes of each pilot. Anyway, a general use case scenario may be identified as follows:

1. A user ***would like to discover*** relevant information regarding his/her area of interest, theme and other preferences. A user e.g. searches for all kind of available information related to European Noise Directive in the area on the border of the Czech Republic, Slovakia and Austria.
2. On contrary to Web searching engines, the (Open) Micka enables to define **advanced *(multiple) searching criteria***, such as to draw a rectangle in a map to define the area that I am interested in, to define quality of information I am interested in (such as spatial accuracy higher than one meter) or to define the responsible authority. E.g. I would like to obtain only noise measurements from official mapping authorities.
3. A user than ***obtains relevant (meta)information*** on all the available resources he/she was searching for. He/she may look into details as well as see all the related resources that provides links to other applications. E.g. a user discovers a NoiseDataset that fulfils all his/her criteria and would like to see a preview of such dataset on a map, see the legal act under which the dataset was created, have a link for the sensor measurement that was conducted in order to populate the NoiseDataset or use a link to the e-shop to buy the dataset.
4. From a producer's perspective, a producer may import his/her metadata from another system or create them manually.
5. A producer than decides which metadata will be published, i.e. made available over the internet.

<table>
<tr><td colspan="2">ID</td><td>Lesprojekt</td></tr>
<tr><td colspan="2">Responsible partner</td><td>Lesprojekt</td></tr>
<tr><td colspan="2">Component name</td><td>Open Micka</td></tr>
<tr><td colspan="2">Functionalities offered</td><td>Metadata management,
Metadata discovery</td></tr>
<tr><td>Data input</td><td>Description</td><td>ISO19115, ISO19119/ISO19139
Manual</td></tr>
</table>

11.12 Layman

A data management component is required to load data into the platforms data stores. For some well-known formats, this can be an automated process. For heterogeneous user data sources, data management might require creation of custom per-data-source scripts.

Layman (API user interface through HS Layers NG), depends on GeoServer

For easy management, access control and publishing of geodata, the LayMan server tool will be used. The server will enable publishing of geospatial data. The server offers REST API. Two models are available:

- layer: visual representation of single vector dataset (i.e. ShapeFile or GeoJSON)
- map: collection of layers

Accepts data in GeoJSON, ShapeFile, Styled Layer Descriptor, Symbology Encoding, or HSLayers Map Composition format

- Even large files can be uploaded from a browser
- Asynchronous upload and processing
- Each vector dataset is automatically imported into PostGIS database
- Provides URL endpoints
    - Web Map Service (WMS)
    - Web Feature Service
    - thumbnail image

<table>
<tr><td colspan="2">ID</td><td>Lesprojekt</td></tr>
<tr><td colspan="2">Responsible partner</td><td>Lesprojekt</td></tr>
<tr><td colspan="2">Component name</td><td>Layman</td></tr>
<tr><td colspan="2">Functionalities offered</td><td>Data management</td></tr>
<tr><td rowspan="3">Data input</td><td>Description</td><td>Vector data</td></tr>
<tr><td>Format</td><td>WMS, WFS, KML, WCS,JSON, RDF….</td></tr>
<tr><td>Standard adopted</td><td>OGC v standards</td></tr>
<tr><td rowspan="3">Data output</td><td>Description</td><td>…</td></tr>
<tr><td>Format</td><td>WMS, WFS, WCS, KML, GeoJSON</td></tr>
<tr><td>Standard adopted</td><td>WMS, WFS, WCS, KML, GeoJSON</td></tr>
<tr><td colspan="2">Integration requirements</td><td>API</td></tr>
</table>

11.13 Sentinel 2 timeseries

To process Copernicus data, users can currently choose between more than 5 public cloud providers, and a myriad of platforms providing processing services, each different from the others. To make data processing easier for researchers, the European Commission has started the H2020 project openEO. It is set up to develop an open API to connect R, python, JavaScript and other clients to big Earth observation cloud back-ends in a simple and unified way.

The data in an openEO service are exposed as a 'data cube', irrespective of how the data is stored internally. As a result, users of openEO will no longer need to deal with individual files, formats, and EO product catalogues. openEO makes the user's life easy.

The openEO API (https://open-eo.github.io/openeo-api/) defines a HTTP API that lets cloud back-ends with large Earth observation datasets communicate with front end analysis applications in an interoperable way. As an overview, the openEO API specifies how to:

- discover which Earth observation data and processes are available at cloud back-ends,
- execute (chained) processes on back-ends,
- run user-defined functions (UDFs) on back-ends where UDFs can be exposed to the data in different ways,
- download (intermediate) results, and
- manage user content including billing.

As an operational predecessor for the openEO project, VITO developed the Time Series Viewer, a web service which allows you to calculate the time series for pixels and polygons. You can integrate these Web services into your application. The full REST API documentation can be found here: https://proba-v-mep.esa.int/api/timeseries/apidocs/.

ID		AC-VITO-1
Responsible partner		VITO
Component name		Sentinel 2 timeseries
Functionalities offered		Data processing: get Sentinel-2 and derived products (NDVI, FAPAR, …) timeseries for a given geospatial entity and for a given time interval; values for each timestamp are calculated as the mean over all pixels that fall inside the geospatial entity
Data input	Description	Polygon (geojson) and time interval
	Format	HTTP Post with geojson
	Standard adopted	Propriatry REST interface
Data output	Description	Key-value pairs (timestamp, S2 product value)
	Format	json
	Standard adopted	none
Integration requirements		NA

11.14 CropSAR Description

Clouds remain one of the largest sources of uncertainty in satellite-based optical monitoring of agricultural crops, inducing gaps in time series of biophysical variables and crop status. The CropSAR technology was developed to provide a solution to this problem. By being independent of weather conditions, the technique provides more observations during essential growth stages such as plant emergence and harvest.

CropSAR relies on observations made by Sentinel-1, a constellation of two radar satellites. A radar does not depend on reflected sunlight, but instead sends out its own energy pulse and measures the return signal after interaction with the surface. In the vegetation case, instead of giving an indication on biophysical processes in the plant, radar backscatter rather contains information on the structure and moisture content of vegetation and the underlying soil. However, even though optical and radar sensors see completely different things, their measurements are nevertheless correlated, as both hold information on the vegetation status. It's exactly that correlation that CropSAR exploits to fill in the cloud-induced gaps in the optical measurements.

Using a powerful GPU cluster and state-of-the-art neural network technologies, the CropSAR algorithms was trained to identify the temporal correlation between Sentinel-1 and Sentinel-2 and exploit this correlation to fill gaps in Sentinel-2 using additional information from Sentinel-1.

CropSAR takes as input cloud-interrupted time series of Sentinel-2 fAPAR and adds uninterrupted time series of Sentinel-1 backscatter. The algorithm then returns completely cloud-free time series of fAPAR together with its confidence level. While CropSAR is currently operational in the WatchITgrow platform over Belgium, recent updates in the backend now allow linking CropSAR with Sentinel Hub by Sinergise for global application as well.

ID		AC-VITO-2
Responsible partner		VITO
Component name		CropSAR
Functionalities offered		Sentinel 2 FAPAR/NDVI timeseries – corrected using Sentinel-1 data
Data input	Description	Polygon (geojson) and time interval
	Format	HTTP Post with geojson
	Standard adopted	Proprietary REST interface
Data output	Description	Key-value pairs (timestamp, S2 product value)
	Format	json
	Standard adopted	none
Integration requirements		None

11.15 WatchItGrow

The WatchITgrow (https://watchitgrow.be/en) application has been introduced in paragraph **Fehler! Verweisquelle konnte nicht gefunden werden.** on the system overview.

ID		AC-VITO-3
Responsible partner		VITO
Component name		WatchITgrow
Functionalities offered		Web application for viewing meteo data, satellite imagery (Sentinel 1 and 2) and derived products (NDVI, FAPAR, fCover, ...) on a regional scale. Also farmer-related or field-related information can be entered, and timeseries for a given geospatial entity (field) and for a given time interval can be queried and displayed; values for each timestamp are calculated as the mean over all pixels that fall inside the geospatial entity
Data input	Description	Web based application
	Format	http
	Standard adopted	None
Data output	Description	Web based application (maps, timeseries)
	Format	http

	Standard adopted	none
Integration requirements		NA

11.16 AVR Connect

To help the modern farmer face the challenges of modern agriculture AVR has fully linked its new Puma with the internet, as illustrated by its fitting name: Puma 4.0.

The web connectivity indicates that sensors positioned in various locations on the Puma collect data from the field and send them online to the personal user platform AVR Connect. The platform can visualise a variety of data including:

- Trips management: route to and from the fields, harvest duration, waiting times - if any - clearly displayed
- geofencing
- real time position of the machine
- settings and parameters at a distance
- remote update option and
- live overview of all Puma screens and parameters, with time recording. Some machine settings can also be linked with quality reports when delivering a load of potatoes.
- integrated yield measurement

The platform can also accommodate other applications and combines this data as well so that they reinforce each other.

AVR Connect is an open platform allowing, if desired, the sharing of data with other packages through APIs. Link-ups with WatchITgrow, Akkerweb, John Deere Operations Center, etc. will be possible in the near future.

ID		AC-AVR-1
Responsible partner		AVR
Component name		AVR Connect
Functionalities offered		Data storage and retrieval for machine data from in-field operations
Data input	Description	REST API for data retrieval
	Format	TBD
	Standard adopted	TBD
Data output	Description	Machine data
	Format	XML
	Standard adopted	ISOXML
Integration requirements		NA

11.17 Decision Support System

Animal Welfare Decision Support System (DSS) will give integrated insight on animal welfare and will suggest corrective actions to the breeding farmer.

ID	AC-ENG-01

European Union
European Regional Development Fund

<table>
<tr><td colspan="2">Responsible partner</td><td>ENG</td></tr>
<tr><td colspan="2">Component name</td><td>Decision Support System</td></tr>
<tr><td colspan="2">Functionalities offered</td><td>Data Management
Data Storage
Database Integrity and maintenance
Data Visualization
User interface
Data Analytics
Data Synchronization
Data Integration
Data Mash-up
Data Harmonization
Multiple Data Sources</td></tr>
<tr><td rowspan="3">Data input</td><td>Description</td><td>Data coming from devices for rumination, eating habits and respiration monitoring (AfiCollar), devices for the separation of dairy yield that is higher and lower quality (AfiLab), pedometer (AfiActII) which monitors the rest of the animal, Data Log devices for temperature control and from Milking robot which collects information on electrical conductivity, parameter correlated with the incidence of mastitis.</td></tr>
<tr><td>Format</td><td>CSV</td></tr>
<tr><td>Standard adopted</td><td>CSV</td></tr>
<tr><td rowspan="3">Data output</td><td>Description</td><td>Suggested actions for the farmer to optimize animals' welfare.</td></tr>
<tr><td>Format</td><td>File (CSV, XML), Query, Java Class, Script (Groovy, Javascript, Embedded Javascript or ECMAScript), Qbe query over the metamodel, Custom, Flat, Ckan, Federated,</td></tr>
<tr><td>Standard adopted</td><td>CSV, SQL, NGSI, REST, JSON</td></tr>
<tr><td colspan="2">Integration requirements</td><td>Other DEMETER component, APIs, GUI, etc.</td></tr>
</table>

11.18 Traceability Decision Support System

Traceability Decision Support System (DSS) will offer to the processing company a prediction of the milk quality based on data collected by the processing farm. Moreover, the DSS will provide suggestions about what to do to improve critical results.

<table>
<tr><td colspan="2">ID</td><td>AC-ENG-02</td></tr>
<tr><td colspan="2">Responsible partner</td><td>ENG</td></tr>
<tr><td colspan="2">Component name</td><td>Traceability Decision Support System</td></tr>
<tr><td colspan="2">Functionalities offered</td><td>Data Management
Data Storage
Data Visualization
Data Analytics
Data aggregation
Multiple Data Sources</td></tr>
<tr><td rowspan="3">Data input</td><td>Description</td><td>Data coming from devices MilkoScan FTIR (characteristics of all milk collected) and Milk Box MKII (fresh milk composition analysis).</td></tr>
<tr><td>Format</td><td>CSV</td></tr>
<tr><td>Standard adopted</td><td>CSV</td></tr>
<tr><td>Data output</td><td>Description</td><td>A prediction of the milk quality and suggestions about what to do to improve critical results</td></tr>
</table>

	Format	File (CSV, XML), Query, Java Class, Script (Groovy, Javascript, Embedded Javascript or ECMAScript), Qbe query over the metamodel, Custom, Flat, Ckan, Federated,
	Standard adopted	CSV, SQL, NGSI, REST, JSON
Integration requirements		Other DEMETER component, APIs, GUI, etc.

11.19 Traceability System

Traceability System component shall tackle requirements for data integrity, data security and tamper resistance, exploiting distributed ledger technology to store validated data concerning production process coming from other DEMETER devices, and exposing API for retrieval of previously stored and validated information.

ID0		AC-ROT-01
Responsible partner		Rotechnology
Component name		Traceability System
Functionalities offered		Data Storage Data Integrity Data Security Data Access
Data input	Description	Names and addresses, production data, data describing characteristics and composition of milk, ready to be stored data from any other device in each production step.
	Format	JSON, CSV, or TBD according to other DEMETER components
	Standard adopted	JSON, CSV, or TBD according to other DEMETER components
Data output	Description	Names and addresses, production data, data describing characteristics and composition of milk, data identifying each production step.
	Format	JSON, CSV, or TBD according to other DEMETER components
	Standard adopted	JSON, CSV, or TBD according to other DEMETER components
Integration requirements		APIs, GUI

11.20 Automated Agricultural Process Documentation Engine

ID		AC-M2X-1
Responsible partner		m2Xpert
Component name		Automated Agricultural Process Documentation Engine
Functionalities offered		Processing and analysis of GPS data in order to respond with a comprehensive set of data delivering translated process documentation.
Data input	Description	Cleaned GPS tracking data + circumstantial process data
	Format	TBD
	Standard adopted	TBD
Data output	Description	Documentation data for the process
	Format	JSON
	Standard adopted	TBD
Integration requirements		TBD

11.21 Automated Agricultural Process Documentation Staging System

ID		AC-M2X-2
Responsible partner		m2Xpert
Component name		Automated Agricultural Process Documentation Staging System
Functionalities offered		Integration, staging and data pre-processing of GPS and circumstantial data in order to enable AC-M2X-1 run with increased performance
Data input	Description	Raw GPS tracking data + circumstantial process data
	Format	TBD
	Standard adopted	TBD
Data output	Description	Cleaned GPS tracking data + circumstantial process data
	Format	JSON
	Standard adopted	TBD
Integration requirements		TBD

11.22 Agricolus FMIS

The Agricolus FMIS is the main interface that provides to the users a set of several functions to describe and organize all the farm-related data and information:

- a field mapping function allows the user to draw on the map the fields as an associate to them all the relative agronomic data
- for each field, the user can choose a crop, the sowing or transplanting date, the crop variety and all the basic field information:
  - irrigation systems
  - an interface to support the user to enter and elaborate the soil analysis data
  - collect information about the field operations like irrigation, fertilisation, harvest, soil working

The Agricolus FMIS manage the association of actual weather and weather forecast data and all the IoT sensors available in the farm, Remote Sensing data sources and RS elaboration pipeline and several modelling and DSS tools. The Olive DSSs will be better described later.

ID		AC-AGRI-1
Responsible partner		AGRICOLUS
Component name		Agricolus
Functionalities offered		User interface for field mapping Spatial geometry design Crop assignment to the field Crop operations Data analysis Weather Forecast Issues Agronomic management of farm Visualization Satellite imagery Alert for pest and diseases Decision Support System GIS
Data input	Description	Sensor data from the field Sensor data from weather station Manual data from user External Web Services
	Format	JSON
	Standard adopted	ISOBUS
Data output	Description	NGSI
	Format	JSON, CSV
	Standard adopted	NGSIv2 and NGSI-LD
Integration requirements		APIs

11.23 Agricolus Water Decision Support System

The Agricolus Water DSS is based on a water balance model considering weather, soil and crop condition. The modelling approach will be based on the equation applied to the soil layer explored by roots. Crop evapotranspiration losses will be evaluated at the orchard and patch level. A set of algorithms simulate the reference crop evapotranspiration ET0, according to the available weather parameters, the maximum crop evapotranspiration ETM and the real crop evapotranspiration ETR. ETM will be obtained multiplying ET0 by a specific crop coefficient (kc), the function of the development (phonological stage) and ETR will be obtained multiplying ETM by a specific water limitation factor. Kc dynamic during crop development will be estimated following the phenological stages. The soil data will be used to estimate all the needed hydraulic property of the soil. A sub-model of the plant phenological stage will be used to estimate the crop coefficient. The user will get daily estimation of the water content, and after definite a minimum and maximum threshold the user will get if the irrigation is needed and what is the suggested amount. The system can adapt itself if the user enters the actual irrigation water. If the user has the irrigation plant parameters, the system can produce the opening time and the suggested shift.

ID		AC-AGRI-2
Responsible partner		Agricolus
Component name		1. Agricolus Water Decision Support System
Functionalities offered		Data analysis User Interface
Data input	Description	Weather data FMIS data (crop, field location, soil analysis) irrigation log
	Format	JSON
	Standard adopted	NGSI for weather data, geoJSON for spatial data
Data output	Description	Water balance (daily water content, suggested irrigation)
	Format	JSON
	Standard adopted	NGSI (to be checked)
Integration requirements		It can be integrated to FMS and other DEMETER weather provider

11.24 Agricolus Nutrient Decision Support System

The Agricolus Nutrient DSS is based on a balance model connected with a plant model estimating the phenology and the nutrient requirement. The most complex model involves nitrogen estimation. Soil texture, properties and variability will be taken into account to allow the production of soil maps to be used to estimate the actual nitrogen content and the potential contribution of soil organic matter mineralisation.

The crop requirements are estimated from the expected yield of the crop and some phenological parameters which varies according to the age and the vigour of the crop itself; the nitrogen inputs are estimated from the actual organic and mineral fertilisation log, the nitrogen stored within the permanent structures of the crop (roots, woody stems) and the part of the nitrogen coming from the residues of the previous crop (and fertilizers that have been provided); a set of models estimates the losses due to leaching, de-nitrification and volatilization. Along with the nitrogen model, there will be some simulation models for phosphorus, potassium and a system to estimate the influence of farming practices on the Soil Organic Matter.

The model will obtain all this data from the FMIS DEMETER interface, and will use the weather data needed by the several model components. The user will obtain the expected optimal nutrient doses in amount suggesting also how the distribution should be made in space and time.

ID		AC-AGRI-3
Responsible partner		Agricolus
Component name		Agricolus Nutrient Decision Support System
Functionalities offered		Data analysis User Interface
Data input	Description	Weather data FMIS data (crop, field location, soil analysis) fertilisation log
	Format	JSON
	Standard adopted	NGSI for weather data, geoJSON for spatial data
Data output	Description	Water balance (daily water content, suggested irrigation)
	Format	JSON
	Standard adopted	NGSI (to be checked)
Integration requirements		It can be integrated to FMS and other DEMETER weather provider

11.25 Agricolus Olive Fruit Fly Decision Support System

The olive fruit fly, Bactrocera oleae is the key pest of Olea europaea L. (olive tree), widespread in the olive producing areas of the Mediterranean Basin. B. oleae lays eggs inside olive fruit, causing pulp consumption by larvae, and premature fall of olives, thus affecting fruit yield and quality. Like any other insect pest, B. oleae development depends on air temperature. A set of models and decision tools will be provided to estimate the potential infestation index at the beginning of the season depending on the winter and spring environmental condition in the olive groves. Moreover, the average total annual infestation will be forecasted by the weather pattern of previous winter, spring and current summer.

A reliable forecasting system is essential to regulate the use and the timing of control treatments in a climate change scenario. The models will estimate also the mortality and fertility rate of the olive fruit fly and the on-settings of the multiple generations. The purpose is to obtain an efficient pest management strategy that can be achieved by combining climate variables with agricultural information in the field. This is mandatory in area-wide pest management approach to coordinate the timing of treatments at farm level, particularly in the early season.

ID		AC-AGRI-4
Responsible partner		Agricolus
Component name		Agricolus Olive Fruit Fly Decision Support System
Functionalities offered		Data analysis User Interface
Data input	Description	Weather data FMIS data (crop, field location, soil analysis) spraying log
	Format	JSON
	Standard adopted	NGSI for weather data, geoJSON for spatial data
Data output	Description	Water balance (daily water content, suggested irrigation)
	Format	JSON
	Standard adopted	NGSI (to be checked)
Integration requirements		It can be integrated to FMS and other DEMETER weather provider

11.26 Zoetis Data visualization

ID		Data visualization provided by ZOETIS
Responsible partner		…
Component name		…
Functionalities offered		Data analysis User interface
Data input	Description	Sensor data from tractor Production data Etc.
	Format	XML, etc.
	Standard adopted	e.g. ISOBUS
Data output	Description	…
	Format	XML, etc.
	Standard adopted	e.g. OGC WFS
Integration requirements		FMS, Other DEMETER component, APIs, etc.

11.27 Lely management system

ID		Lely management system
Responsible partner		TEAGASC
Component name		… Data management system
Functionalities offered		Data analysis User interface data processing, data analytics, visualization
Data input	Description	Sensor data from automatic milking system Production data
	Format	CSV
	Standard adopted	
Data output	Description	… Milk yield, composition and conductivity
	Format	EXCEL
	Standard adopted	
Integration requirements		FMS, Other DEMETER component, APIs, etc.

11.28 Tyndall Bespoke Analog Front End

ID		Bespoke Analog Front End
Responsible partner		Tyndall
Component name		…
Functionalities offered		Data readout Data analysis User interface data processing, data analytics, visualization
Data input	Description	Sensor data from serum and milk
	Format	CSV, text file
	Standard adopted	
Data output	Description	Concentrations of Bio-markers
	Format	EXCEL
	Standard adopted	
Integration requirements		FMS, Other DEMETER component, APIs, etc.

11.29 poultryNET

poultryNET is a cloud-based solution that provides easy-to-use decision support instructions based on the real-time observations of the parameters of interest and digitized domain expertise enabling farmers to manage all steps in the broilers production. It is aimed to help farmers to produce high-quality meat, while reducing negative environmental impact and respecting the animal welfare. Increased of energy usage, optimized food and water consumption and better meat quality are the main benefits.

ID		AC-<DNET>-<1>
Responsible partner		DNET
Component name		poultryNET
Functionalities offered		Data analysis and insights User interface with visualization Chatbot Data storage
Data input	Description	Data from environmental sensors, audio/video streams Production data (feed level, feed and water consumption, power supply)
	Format	JSON
	Standard adopted	MQTT
Data output	Description	
	Format	
	Standard adopted	
Integration requirements		APIs, data formats.

11.30 agroNET

agroNET is a cloud-based platform designed to enable optimization of the agriculture production, reduction of production costs, as well as increase of the yield and the crop quality and, eventually, the profit. It acts as an interoperability hub providing the complete farm assets (tractors, machinery, irrigation systems, diesel generators, weather stations, insect traps, sensors, etc.) and activity management and monitoring. Thanks to the rich set of data available, agroNET provides a range of expert data analytics services through different expert modules. Each module provides information in the form of easy to follow instructions based on the embedded agriculture expertise and real-time measurements collected from in-field devices.

ID		AC-DNET-1
Responsible partner		DNET
Component name		agroNET
Functionalities offered		Data analysis and insights User interface with visualization Pest and disease prediction Data storage
Data input	Description	Data from environmental sensors, smart pheromone traps
	Format	JSON
	Standard adopted	MQTT
Data output	Description	
	Format	
	Standard adopted	
Integration requirements		APIs, data formats.

11.31 OriginTrail Decentralized Network (ODN)

The OriginTrail Decentralized Network (ODN) is built for data integrity and validation across organizations and across different IT systems. The OriginTrail protocol - open-source, blockchain-powered data exchange protocol - drives data exchanges in a scalable, interoperable, and immutable way, resulting in an integrity-driven supply chain exchange. The protocol is based on distributed ledger technology (DLT), powerful graph data structures, and global data standards, most notably GS1 EPCIS standard for supply chain event-based tracking. The OriginTrail technology will enable connectivity among different IT systems for the pilot and support blockchain-based data exchange, to ensure trust and transparency between actors in the value chain.

The open-source project repository for OriginTrail is available at: https://github.com/origintrail

ID		
Responsible partner		Prospeh
Component name		OriginTrail Decentralized Network
Functionalities offered		Peer 2 peer data exchange Data integrity validation via blockchain Data interconnectivity Ingestion of data structured in different data formats
Data input	Description	Fragmented supply chain stakeholder information
	Format	XML & JSON
	Standard adopted	GS1 CBV & EPCIS
Data output	Description	Consolidated supply chain information from all stakeholders
	Format	JSON-LD
	Standard adopted	JSON-LD
Integration requirements		Setting up the network node infrastructure to appropriate devices.

11.32 Network Operating System (nOS)

The Network Operating System (nOS) is designed to enable integration among different data creating systems in a supply chain, different blockchain ecosystems and the OriginTrail protocol.

The Network Operating System (nOS) is a hub for open industry data exchange, combining the benefits of the blockchain, global standards, and enterprise-grade software. It provides a single interface for connecting, rather than replacing, existing legacy IT systems with different blockchain ecosystems and the OriginTrail protocol through features such as:

- API access for enterprise software and external services;
- Powerful knowledge graph data structures;
- Powered by global standards for data exchange (GS1, W3C, Web of Things, etc.);
- Strong encryption for confidential data;
- Connectivity with Ethereum, Hyperledger Fabric, and other blockchain solutions.

The nOS enables:

- Setup of consortia networks with partners;
- Easy exchange and matching of data between partners;
- Provisioning of public and private OriginTrail network nodes;
- Utilization of different public and consortium blockchain networks;

Development and integration of applications (e.g. Track & Trace, Provenance).

ID		
Responsible partner		Prospeh
Component name		Network Operating System
Functionalities offered		Data processing & conversion Device integration Applications utilizing underlying OriginTrail Network and blockchain
Data input	Description	Fragmented supply chain stakeholder information
	Format	XML & JSON
	Standard adopted	GS1 CBV & EPCIS
Data output	Description	Visualized supply chain information through different applications, additionally making data available through a user-friendly API
	Format	JSON-LD
	Standard adopted	JSON-LD
Integration requirements		Integrating with nOS applications

11.33 Product passport

Product passport is a cloud-based platform designed to support creation of a transparent and trustworthy supply chain. It enables creation of standards-based unique identifiers for individual product items and records all relevant events throughout the lifetime of each item, from the production/manufacturing time to disposal and, eventually, recycling. It provides open APIs for other solutions to leverage identities and events recorded/stored throughout the food supply chain.

ID		AC-DNET-2
Responsible partner		DNET
Component name		Product passport
Functionalities offered		Unique identities Event tracking Interface to DLT/blockchain
Data input	Description	Data about product items and related events
	Format	JSON
	Standard adopted	MQTT
Data output	Description	
	Format	
	Standard adopted	
Integration requirements		APIs, data formats.

11.34 TagItWine

TagItWine is a smartphone application designed for consumers as their main entry point into visualization of the supply chain activities. It enables consumers to scan wine labels/tags in order to obtain information about the wine, the production process and other information attached to each individual bottle of wine.

ID		AC-UDG-1
Responsible partner		UDG
Component name		TagItWine
Functionalities offered		Scanning of labels Interaction with Product passport
Data input	Description	Data about product items and related events
	Format	JSON
	Standard adopted	MQTT
Data output	Description	
	Format	
	Standard adopted	
Integration requirements		APIs, data formats.

11.35 Feedback APP

ID		AC-52-3-UPM-1
Responsible partner		UPM
Component name		Feedback APP
Functionalities offered		Mobile app for end-users to provide feedback
Data input	Description	Data from users participating un consumer's workshops
	Format	Forms, sensor information coming from mobile phone, such as location, time, etc.
	Standard adopted	Android / iOS
Data output	Description	Processed data to be stored in production database
	Format	JSON, Database
	Standard adopted	JSON, SQL
Integration requirements		APIs, data formats.

11.36 AFARCloud Middleware

ID		AC-52-3-AFC-1
Responsible partner		UPM & TECNALIA
Component name		AFARCloud Middleware
Functionalities offered		MQTT agent from AFARCloud Middleware that allows data acquisition and management of IoT devices (sensors and actuators): It will be extended to be compliant with DEMETER data models and to be integrated into its infrastructure.
Data input	Description	Data from IoT devices (sensors + actuators).
	Format	JSON
	Standard adopted	JSON messages over HTTP REST or MQTT.
Data output	Description	Data complying with DEMETER information models
	Format	JSON
	Standard adopted	JSON messages over HTTP REST or MQTT.
Integration requirements		This middleware is to be integrated in DEMETER infrastructure

11.37 ControlBee

ControlBee is a dedicated solution for beekeepers. The project is based on a network of distributed sensors that collect information about the physical conditions of beehives. ControlBee also provides geographic location information for apiaries.

ID		AC-IDEATRONIK-1
Responsible partner		IDEATRONIK
Component name		ControlBee
Functionalities offered		Functionalities include: - adding sensors - monitoring geographic position of hive - notification of threats
Data input	Description	Hive sensor data, apiary geographic position
	Format	TBD
	Standard adopted	TBD
Data output	Description	Notifications for beekeepers apiary geographic position
	Format	Data displayed in mobile application
	Standard adopted	TBD
Integration requirements		HTTPS / REST API

11.38 siloNET

siloNET is a cloud-based platform designed to enable monitoring of the amount of feed stored in silos on the farms and to automate feed ordering process thus reducing the costs and increasing efficiencies on both farmers and feed production sides. Further to that, the solution generates inputs for monitoring of the breeding process.

<table>
<tr><td colspan="2">ID</td><td>AC-DNET-2</td></tr>
<tr><td colspan="2">Responsible partner</td><td>DNET</td></tr>
<tr><td colspan="2">Component name</td><td>siloNET</td></tr>
<tr><td colspan="2">Functionalities offered</td><td>Data analysis and insights
User interface with visualization
Data storage</td></tr>
<tr><td rowspan="3">Data input</td><td>Description</td><td>Data from level measurement sensor</td></tr>
<tr><td>Format</td><td>JSON</td></tr>
<tr><td>Standard adopted</td><td>MQTT</td></tr>
<tr><td rowspan="3">Data output</td><td>Description</td><td></td></tr>
<tr><td>Format</td><td></td></tr>
<tr><td>Standard adopted</td><td></td></tr>
<tr><td colspan="2">Integration requirements</td><td>APIs, data formats.</td></tr>
</table>

12 Annex C - Used Hardware

This section will contain a list of currently identified hardware components to be used in DEMETER and maps them to the pilots. The mapping to the pilots only states where the use of the hardware was indicated. The objective is to provide other WPs with an overview of existing hardware to be taken into consideration. Which applications, hardware, system extensions, data and DEMETER components will be used in the pilot round 1, will be documented in D5.3 Testbed, deployment, system extensions and applications for pilot round 1, which will become available in August 2020.

Hardware	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
Mex06 Datalogger	x	x																		
IPex12 Datalogger	x	x																		
SmartPaddy			x																	
Electric Valves			x																	
UAV Mapping Solutions			x																	
agrometeo Stations								x												
Agronode							x													
Yield sensor												x								
Planting distance Logger												x								
AfiActII														x						
AfiCollar														x						
Datalog														x						

Hardware	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
AfiLab														x						
Milk Box MKII														x						
MilkoScan FTIR														x						
John Deere Sensors					x															
John Deere ECU					x															
GPS tracking device						x														
METOS Weather Station									x											
Automatic Fruit Fly Trap											x									
EAR Tag															x					
Lely robot															x					
Disease Diagnostic System															x					
temperature and humidity sensor	x															x				x
CO_2, light intensity and air flow sensors																x				x
microphones capturing of chicken vocalization																x				x

Hardware	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 1.4	Pilot 2.1	Pilot 2.2	Pilot 2.3	Pilot 2.4	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 4.1	Pilot 4.2	Pilot 4.3	Pilot 4.4	Pilot 5.1	Pilot 5.2	Pilot 5.3	Pilot 5.4
video camera																x				x
Weather Station	x																x			
Pheromone traps																	x			
Asset tracker																	x			
FEDE Sprayer																	x			
QR code labels																	x			x
ControlBee - Hive scale																			x	
ControlBee - Hive sensor																			x	
ControlBee - Control unit																			x	
Vehicle Tracking Device																				x
Silo Level Monitoring																				x

12.1 Mex06

Product ID: Mex06 Datalogger

Category: Radio Controller

Description: Datalogger and controller for outdoor environments for monitoring and remote control. Extra-low consumption to operate with battery and solar panel. Radio communications and configuration by serial port with AT commands.

Inputs/Outputs:

- 2 digital pulse counters for water consumption/water precipitation.
- 4 analog inputs (current and voltage) with adjustable gain.

Communications:

1xRS232, 1xSerial TTL, 1xSDI-12, IEEE 812.15.4

Compatible with wireless modules (GPRS, NBIoT, RF, LoRa, Sigfox)

For more information: www.odins.es

Responsible partner	OdinS
Hardware name	Mex06
Interfaces	MQTT
Dependencies (Direct/indirect)	
Embedded SW	
Owner	OdinS
References	
Data Flow	JSON over MQTT

12.2 IPex12

Product ID: IPex12 Datalogger.

Category: IP controller.

Description: Outdoor high performance datalogger and controller device for remote control and monitoring. Low power consumption to operate with battery and solar panel. Wide range of I/O and communication ports. Configuration with serial port via AT commands.

Inputs/Outputs:

- 5 digital outputs for triggering latch valves from 6V/12V
- 4 digital inputs potential-free contact for counter (up to 10Hz)
- 2 analog inputs for PT100/PT1000 sensors
- 8 analog inputs (current and voltage) with adjustable gain.
- 1 additional digital output with Relay (included).
- 1 additional digital input for general purpose.

Communications:
1xRS232, 1xSDI-12, 1xUSB Host, 1xIPexBUS cable

Compatible with wireless modules (GPRS, NBIoT, RF, LoRa, Sigfox)

For more information: www.odins.es

Responsible partner	OdinS
Hardware name	IPex12
Interfaces	MQTT
Dependencies (Direct/indirect)	
Embedded SW	
Owner	OdinS
References	
Data Flow	JSON over MQTT

12.3 SmartPaddy

The SmartPaddy sensor is a custom salinity and water height sensor, built to withstand the harsh environment of rice paddies. One sensor must be installed in each field and provides real-time measurements of water salinity and height

Responsible partner	ELGO
Hardware name	Salinity & water height sensor
Interfaces	Communication via SMS over a GSM network
Dependencies (Direct/indirect)	GSM network
Embedded SW	Yes, for sending the measurements via a GSM modem
Owner	ELGO
References	https://cordis.europa.eu/project/rcn/100867/factsheet/en
Data Flow	Data are fed to AC-ELGO-1 for data storage and further processing

12.4 Electric Valves

Automated electric input/output valves are used by the SIS-Rice service to remotely control water height in rice fields.

ID	ElectricValves
Responsible partner	ELGO
Hardware name	Electric input/output valves for automated rice water control
Interfaces	Communication via SMS over a GSM network
Dependencies (Direct/indirect)	GSM network; power installation (possibly self-powered via solar cells, but this will be determined in the future)
Embedded SW	Yes, for receiving commands via a GSM modem
Owner	ELGO
References	
Data Flow	They are controlled either by the AC-ELGO-1 component or by the user directly.

12.5 UAV Mapping Solutions

UAVs equipped with multispectral and thermal cameras, which are needed for estimating irrigation requirements of maize crops and for supporting VRA nitrogen fertilisation in rice and maize.

ID	UAV
Responsible partner	ELGO
Hardware name	UAVs equipped with multispectral and thermal camera
Interfaces	Supported multispectral cameras: Parrot Sequoia; MicaSense RedEdge-MX
Dependencies (Direct/indirect)	
Embedded SW	Yes
Owner	ELGO & ICCS
References	
Data Flow	Data are fed to AC-ELGO-2 & AC-ELGO-3 components.

12.6 agrometeo stations

ID	1
Responsible partner	WODR
Hardware name	agrometeo stations
Interfaces	GSM
Dependencies (Direct/indirect)	Indirect
Embedded SW	data loggers with analog and digital sensors
Owner	WODR and partners: other regional advisory centres, Institute of Plant Protections, farmers associations and private farmers
References	
Data Flow	sensors - data loggers - GSM - producers' servers - EPSU database

12.7 agronode

ID	Lesprojekt
Responsible partner	Lesprojekt
Hardware name	AgroNode
Interfaces	Lora, Sigfox, NbIoT, GPRS
Dependencies (Direct/indirect)	None
Embedded SW	OS
Owner	Lesprojekt
References	
Data Flow	Data are coming to Senslog

12.8 Yield sensor

The new AVR harvesters are equipped with weight sensors that capture detailed data on yield on a 1 Hz basis. The yield sensor is based upon traditional heavy duty weighting sensors where signals are amplified and calibrated.

ID	AVR-01
Responsible partner	AVR
Hardware name	Yield sensor linked to AVR harvester
Interfaces	Yields sensor based on weighing cells, amplifier circuit & complex logic
Dependencies (Direct/indirect)	No – own development
Embedded SW	Yes, software calculating yield with correct position
Owner	AVR
References	
Data Flow	Data is gathered on the machine and put on the CANbus system which is then taken by the telematics unit to be sent to AVR Connect (see further)

12.9 Planting distance Logger

The planting distance sensor is a technical data element on the planting implement, that sends its data to the tractor via ISOBUS communication. The telematics unit on the tractor further sends this data to the AVR Connect cloud. AVR will add a physical element to detect missing planted potatoes.

ID	AVR-02
Responsible partner	AVR
Hardware name	Planting distance Logger linked to AVR planter devices
Interfaces	Physical sensor measuring the as applied planting distance using ISOBUS
Dependencies (Direct/indirect)	None
Embedded SW	Yes
Owner	AVR
References	
Data Flow	Data is gathered on the machine and put on the CANbus system, which is then taken by the telematics unit to be sent to AVR Connect

12.10 AfiActII

ID	1
Responsible partner	Maccarese
Hardware name	AfiAct II https://www.afimilk.com/cow-monitoring (Pedometer)
Interfaces	Physic interface (sensor)
Dependencies (Direct/indirect)	
Embedded SW	AfiFarm 5.3
Owner	Maccarese
References	
Data Flow	Animal behaviour

12.11 AfiCollar

ID	2
Responsible partner	Maccarese
Hardware name	AfiCollar
Interfaces	Physic interface (sensor)
Dependencies (Direct/indirect)	
Embedded SW	AfiFarm 5.3
Owner	Maccarese
References	
Data Flow	Animal behaviour

12.12 Datalog

ID	3
Responsible partner	Maccarese
Hardware name	Data Log
Interfaces	Physic interface (sensor)
Dependencies (Direct/indirect)	
Embedded SW	TBD
Owner	Maccarese
References	
Data Flow	Animal temperature

12.13 AfiLab

ID	4
Responsible partner	Maccarese
Hardware name	AfiLab[8]
Interfaces	Physic interface (to be applied to the production line)
Dependencies (Direct/indirect)	
Embedded SW	AfiFarm 5.3
Owner	Maccarese
References	
Data Flow	Separation of dairy yield (higher and lower quality)

12.14 Milk Box MKII

ID	5
Responsible partner	Latte Sano
Hardware name	Milk Box MKII (Automatic lactating devices)
Interfaces	Physic interface (to be applied to the production line)
Dependencies (Direct/indirect)	
Embedded SW	To be defined
Owner	Lattesano
References	
Data Flow	All data relating to the "milk collection" from farmer (milk composition and quality)

[8] https://www.afimilk.com/inline-milk-lab-parlor

12.15 MilkoScan FTIR

ID	6
Responsible partner	Latte Sano
Hardware name	MilkoScan FT1 - NIR
Interfaces	Physic interface (to be applied to the production line)
Dependencies (Direct/indirect)	
Embedded SW	
Owner	Latte Sano
References	
Data Flow	Characteristics of all milk collected.

12.16 John Deere Sensors

ID	1
Responsible partner	John Deere
Hardware name	Sensors
Interfaces	To be defined
Dependencies (Direct/indirect)	Direct
Embedded SW	no
Owner	Farmer
References	-
Data Flow	From Sensor to Engine Control Unit

12.17 John Deere ECU

ID	2
Responsible partner	John Deere
Hardware name	Engine Control Unit
Interfaces	To be defined
Dependencies (Direct/indirect)	indirect
Embedded SW	Yes – internal engine control software
Owner	Farmer
References	-
Data Flow	From Sensor to Engine Control Unit and from there to the not yet defined hardware which will monitor the data

12.18 GPS tracking device

ID	#1 GPS tracking device
Responsible partner	m2Xpert
Hardware name	GPS Tracker
Interfaces	• Constant GPS Tracking • Push of GPS + Timestamp data via mobile communication network to staging system • Usage of proprietary data format
Dependencies (Direct/indirect)	• Direct: Energy level in tracking device • Indirect: Availability of mobile communication network connection
Embedded SW	Proprietary
Owner	m2Xpert / Hardware supplier
References	TBD
Data Flow	TBD

12.19 METOS Weather Station

The main implemented hardware will be a set of weather stations. The weather station may change according to farmers preference and pre-existing hardware. We will consider as a reference system the METOS weather station by Pessl instruments, which is the most common device used by our customers. We have already developed a set of different weather data sources that are harmonized and entered in the Agricolus solution. For the scope of the pilots, the weather station will have an air Temperature and Relative Humidity sensor, a Rain Gauge and a Leaf Wetness sensor. Radiation, Wind and soil temperature and humidity can be optionally used to improve the result of the models.

ID	1
Responsible partner	Agricolus
Hardware name	Weather station
Interfaces	Network connection to get weather data in real time over GSM/GPRS. Data is regularly uploaded to FieldClimate platform (from Pessl) where we can access it from any place at any time in real-time.
Dependencies (Direct/indirect)	
Embedded SW	Pessl API
Owner	Agricolus with Pessl provider
References	http://metos.at/imetos33/
Data Flow	Agricolus take input directly from the Pessl API. Data includes temperature, humidity, rainfall, leaf wetness

12.20 Automatic Fruit Fly Trap

To be developed as part DEMETER. Details will follow.

12.21 EAR Tag

ID	Ear tag
Responsible partner	Zoetis
Hardware name	EAR tag
Interfaces	Physical interface
Dependencies (Direct/indirect)	Indoor housing system
Embedded SW	
Owner	
References	
Data Flow	Movement, rumination, heat detection

12.22 Lely robot

ID	Automatic milking system
Responsible partner	TEAGASC
Hardware name	Lely robot
Interfaces	Physical interface
Dependencies (Direct/indirect)	
Embedded SW	yes
Owner	Lely
References	
Data Flow	Milk yield, flow, conductivity and composition, time of milking,

12.23 Disease Diagnostic System

ID	Disease Diagnostic System
Responsible partner	Tyndall
Hardware name	…
Interfaces	Physical interface
Dependencies (Direct/indirect)	
Embedded SW	yes
Owner	Tyndall
References	
Data Flow	Excel format

12.24 Temperature and humidity sensor

A device equipped with temperature and humidity sensor used as a part of the environment monitoring setup. LoRa communication interface is used to transmit data. The device is battery powered.

ID	
Responsible partner	DNET
Hardware name	Device with temperature and humidity sensor
Interfaces	LoRa
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.25 CO2, light intensity and air flow sensors

A device equipped with CO_2, light intensity and air flow sensors. LoRa communication interface is used to transmit data.

ID	
Responsible partner	DNET
Hardware name	Device with CO_2, light intensity and air flow sensors
Interfaces	LoRa
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.26 Microphones capturing of chicken vocalization

A device equipped with microphones enabling capturing of chicken vocalization. WiFi or 3G/4G communication interface is used for communication. The initial audio processing is done on the edge.

ID	
Responsible partner	DNET
Hardware name	Vocalization capturing and analysis
Interfaces	
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.27 Video camera

A video camera providing continuous 24/7 video stream from the farm. WiFi or 3G/4G communication interface is used for communication.

ID	
Responsible partner	DNET
Hardware name	Video camera
Interfaces	
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.28 Weather Station

Weather station providing parameters required for farm management (temperature, humidity, precipitation, air flow, leaf wetness, etc.).

ID	
Responsible partner	DNET
Hardware name	Weather station
Interfaces	API to data provided by agroNET
Dependencies (Direct/indirect)	agroNET
Embedded SW	
Owner	DNET
References	
Data Flow	

12.29 Pheromone traps

Pheromone traps equipped with a camera taking images of the caught insects. 3G communication interface is used to transfer images.

ID	
Responsible partner	DNET
Hardware name	Smart pheromone trap
Interfaces	API to data provided by agroNET
Dependencies (Direct/indirect)	agroNET
Embedded SW	
Owner	DNET
References	
Data Flow	

12.30 Asset tracker

Vehicle and machinery trackers providing information about the location, speed, status, and activity of the vehicle/machine.

ID	
Responsible partner	DNET
Hardware name	Asset tracker
Interfaces	
Dependencies (Direct/indirect)	
Embedded SW	
Owner	DNET
References	
Data Flow	

12.31 FEDE Sprayer

Mobile sprayer used in vineyards.

D	
Responsible partner	FEDE
Hardware name	Sprayer
Interfaces	FEDE sprayers are cloud connected, either using cellular systems GPRS, then being able to communicate in real time while in coverage, or using a download and upload of data packets via Wi-Fi, e.g. when in range at the farm office. The Wi-Fi option is not real-time. FEDE sprayers connect to FEDE's Specialty Crops Platform (SCP). Data interchange with agroNET is foreseen via Cloud2Cloud connection/API
Dependencies (Direct/indirect)	FEDE's Specialty Crops Platform (SCP)
Embedded SW	Proprietary
Owner	FEDE
References	http://fede.specialtycropsplatform.com/index/login
Data Flow	bidirectional, job orders down to machinery, as applied maps and other machinery info up into SCP

12.32 QR code labels

QR code labels for unique identification of bottles.

D	
Responsible partner	DNET
Hardware name	QR code labels
Interfaces	
Dependencies (Direct/indirect)	
Embedded SW	
Owner	DNET
References	
Data Flow	

12.33 ControlBee - Control unit

The central unit collects information from sensors and scales installed on the apiary.

ID	HC-IDEATRONIK-1
Responsible partner	IDEATRONIK
Hardware name	ControlBee - Control unit
Interfaces	Wireless local interface in the 868MHz ISM band. The interface to the application server is via the Internet, HTTPS / JSON.
Dependencies (Direct/indirect)	Has HTTPS / JSON interface to the ControlBee server network service.
Embedded SW	TBD
Owner	IDEATRONIK
References	TBD
Data Flow	In the sensor local network, wireless communication in the ISM 868 MHz band, star network topology, AES encryption, IDEATRONIK own communication protocol. In communication with the server service - HTTPS / JSON.

12.34 ControlBee - Hive sensor

The ControlBee GPS sensor is a small, modern electronic device designed to protect and monitor hives in an apiary. Thanks to it, beekeepers are constantly informed about detected events in the apiary by means of a mobile application. The hive sensor collects information about conditions in a hive such as temperature and shock detection. Hive sensor is an intelligent sensor that detects sabotage situations to the hive, notifies the owner and shows his current position on the map.

ID	HC-IDEATRONIK-2
Responsible partner	IDEATRONIK
Hardware name	ControlBee - Hive sensor
Interfaces	Battery powered wireless sensor. RF communication with the central unit in the ISM 868 MHz band. Own communication protocol developed by IDEATRONIK. Provides vibration and shock detector and temperature measurement.
Dependencies (Direct/indirect)	Communicates with the Central Unit
Embedded SW	TBD
Owner	IDEATRONIK
References	TBD
Data Flow	Wireless communication in the ISM 868 MHz band, star network topology, AES encryption, IDEATRONIK own communication protocol. Service and measurement data. Measurement data from temperature, movement and vibration.

12.35 ControlBee - Hive scale

The hive scale collects information about hive weight. Small and lightweight apiary scale. It has a clear OLED display and a built-in lithium-ion battery. The scale remembers daily and hourly measurements. It works for up to 12 months without the need to charge the battery. It is very easy to assemble and use. When placed under the hive, it is not visible.

ID	HC-IDEATRONIK-3
Responsible partner	IDEATRONIK
Hardware name	ControlBee - Hive scale
Interfaces	Wireless scales for the hive. Communicates RF with the central unit in the ISM 868MHz band. Own communication protocol developed by IDEATRONIK. Provides information about the weight of the hive.
Dependencies (Direct/indirect)	Communicates with the Central Unit
Embedded SW	TBD
Owner	IDEATRONIK
References	TBD
Data Flow	Wireless communication in the ISM 868 MHz band, star network topology, AES encryption, IDEATRONIK own communication protocol. Service and measurement data. Measurement data on the amount of honey in the hive based on weight measurement.

12.36 Silo level monitoring

A radar-based silo monitoring device providing information about the level of feed in the silo. Wi-Fi or 3G/4G communication interface is used for communication.

ID	
Responsible partner	DNET
Hardware name	Silo level monitoring
Interfaces	
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.37 Vehicle tracking devices

Vehicle tracking devices providing information about the location and activities of a vehicle. 3G/4G communication interface is used for communication.

ID	
Responsible partner	DNET
Hardware name	Video camera
Interfaces	
Dependencies (Direct/indirect)	poultryNET
Embedded SW	
Owner	
References	
Data Flow	

12.38 AgIoT – Sensor and Machinery gateway

AgIoT is modular and open source IoT solution for agrofood domain. AgIoT is open source IoT solution that can be applied to the domain of Agrifood, that is interoperable with ISOBUS and FIWARE standards and portable solutions for different contexts application AgIoT concept R&D by INESC TEC. AgIoT is modular and open source IoT solution for agrofood domain. AgIoT is open source IoT solution that can be applied to the domain of Agrifood, that is interoperable with ISOBUS and FIWARE standards and portable solutions for different contexts application.

AgIoT module with Sensor Add-on will enable:

- Update agricultural machinery and tools to acquired crop (Canopy, Water Stress,..) information during their normal operation
- Update agricultural machinery and tools with variable rate technologies for higher levels of precision during the fertilization and spraying treatments. (by using geo-localisation, including Galileo and EGNOS (the European Geostationary Navigation Overlay Service) receivers.
- Conventional agricultural machinery and implements to operate under prescription maps (ISO-XML files) obtained from FMIS and DSS apps.
- Old agricultural machinery and tools understand prescription maps (ISO-XML files) obtained from FMIS and DSS apps.
- on IOT farm structure (interoperable standards) where any standard ag sensor and actuator may be connected to acquire information about soil, water, macro-nutrients, or crops (because connected systems can talk to each other).
- In-field real time monitoring of pests and diseases
- Alerts concerning insufficient water level in the field and precision irrigation
- LoRa, NB-IOT and Wi-Fi infrastructure in all farm pilot
- Introduce optical sensors to monitor crop growth and phenology.
- Develop decision support systems for optimization of water and energy usage

Using the Sensor Add-on identified above, the following parameters for field monitoring can be measured:

- irrigation scheduling (frequency and duration of watering)
- NPK quantification
- Dynamic of Canopy Size and shape
- Soil moisture

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- Soil temperature
- Rainfall
- Wind
- Sunlight
- Chlorophyll Concentration Index
- Leaf wetness
- Air Temperature
- Relative Humidity
- Soil pH
- Crop reflectance and vegetation indices (e.g. NDVI/EVI/EVA)
- Radiation (PAR included)
- Leaf area index LAI
- Plant diseases and main vectors detection
- Biomass and yield and production related parameters
- Product quality analysis
- Soil analysis for macronutrients and minerals
- Crop growth, canopy dynamics and phenology

ID	38
Responsible partner	INESC TEC
Hardware name	AgIoT - Sensor and Machinery gateway
Interfaces	WiFi, GSM/GPRS, Ethernet, CAN (ISOBUS), RS232, electrovalves control, 4-20mA, general I/O, Analog inputs
Dependencies (Direct/indirect)	Mosquitto (eclipse)
Embedded SW	AgIoT over Linux (openwrt)
Owner	INESC TEC
References	Agiot.inesctec.pt
Data Flow	AgIoT can collect data from sensors and sent data to middleware through MQTT using JSON protocol and can receive commands from MQTT

12.39 AgRob Vxx – Agricultural Robots

AgRob Vxx is a family of Agricultural Robots in TRL7 that can be deployed on pilots using AgIoT modules.

ID	39
Responsible partner	INESC TEC
Hardware name	Agricultural Robots
Interfaces	WiFi, GSM/GPRS, Ethernet, CAN (ISOBUS), RS232, electrovalvules control, 4-20mA, general I/O, Analog inputs
Dependencies (Direct/indirect)	AgIoT
Embedded SW	Linux and ROS, AgIoT over Linux (openwrt)
Owner	INESC TEC
References	Agrob.inesctec.pt
Data Flow	AgIoT can collect data from sensors and sent data to middleware through MQTT using JSON protocol and can receive commands from MQTT

13 Annex D - Used Cloud Services

This section contains a list of currently identified cloud services to be used in DEMETER.

13.1 OpenStack at PSNC

Cloud Service name	OpenStack (HPC at PSNC premises)
Cloud Service components	Data Storage, Data Analytics, Computational power
Cloud Service use	Running FMS+DSS components, storage of data, running prediction and comparison models, data correlation

13.2 OpenStack at Lesproject

Cloud Service name	OpenStack
Cloud Service components	Nova Compute and Cinder Block Storage are the most relevant OpenStack components used
Cloud Service use	We are using private own built cloud

13.3 Azure at Agricolus

Cloud Service name	Azure
Cloud Service components	Data Storage Web component Remote Sensing Services
Cloud Service use	Azure is used to store data (using SQL database service, data storage services for documents and imagery and virtual machine for the application layer.

13.4 Proba-V Mission Exploitation Platform (VITO)

Cloud Service name	Proba-V Mission Exploitation Platform (VITO)
Cloud Service components	Data Storage (Sentinel imagery, field information) Data Analytics (notebooks, VMs)
Cloud Service use	Allow easy access to Proba-V and Sentinel products for end users; open access to end users

13.5 AVR Connect

Cloud Service name	AVR Connect
Cloud Service components	Data Storage
Cloud Service use	Allow access to AVR machinery data

13.6 Azure at DNET

Cloud Service name	Azure

Cloud Service components	IoT hub, Azure SQL…
Cloud Service use	Visualization, analytics, storage, business logic, interaction with other systems.

13.7 Digital Ocean at Prospeh

Cloud Service name	Digital Ocean
Cloud Service components	Cloud instances, Object storage
Cloud Service use	Provisioning, monitoring and backup of network nodes and log storage

14 Annex E - Connectivity and Networking Infrastructures

This section summarises the known connectivity and infrastructure requirements of the identified soft- and hardware component.

Platform	Requirements
Mega Coordinator	Internet access. Exposed HTTP REST and Soap APIs.
Smart Agriculture	Exposes NGSIv2 REST API and NGSI, NGSA-LD data models. MEGA API also adopted.
IPex12	NBIoT, LoRa or GPRS
Mex06	NBIoT, LoRa or GPRS
Smart Irrigation Service for Rice	IPv4/6 connectivity GSM modem Internet access
Smart Irrigation Service for Maize	IPv4/6 connectivity Internet access
Fertilisation Advisory Service for Rice & Maize	IPv4/6 connectivity Internet access
SmartPaddy	GSM network (minimum requirements TBD)
ElectricValves	GSM network (minimum requirements TBD)
Inovagria	IPv4/6 connectivity. Internet access.
EPSU / eDWIN	Connectivity to external data source: FADN database.
SensLog	Internet access. Needs to be accessible to HSLayersNG and OpenMicka. Exposed HTTP REST APIs at dedicated ports. Access to PostgreSQL database L3 connectivity to DB1 and DB2.
HSLayersNG	Internet access. Local connectivity to SensLog and OpenMicka. Access to PostgreSQL database
OpenMicka	Internet access. Local connectivity to HSLayersNG and SensLog. Access to PostgreSQL database ad Web server supporting PHP 7
Layman	Internet access. Local connectivity to HSLayersNG and OpenMicka

Platform	Requirements
	Access to PostgreSQL database, Geoserver and Java
VITO_MEP	Internet access
AVR_harvester	GPRS/4G GPS
AVR_planter_machine	GPRS/4G GPS
Data Management System	IPV4/6 only connectivity Internet access
Decision Support System	IPV4/6 only connectivity Internet access
Traceability System	IPV4/6 only connectivity Internet access 16GB RAM, i7 or later, SSD 512GB DISK Personal Computer per blockchain node
Automated Agricultural Process Documentation Engine	• HTTPS secured Internet access • Remote connectivity to data sources #1 to #3 as well as component AC-M2X-2 Exposed HTTP REST APIs at ports TBD
GPS tracking device	• Mobile Network Connectivity# • Network latency <150ms [redacted]

Platform	Requirements
AFARCloud platform	Internet access. Connection to cloud infrastructures.
AFARCloud platform	LPWAN network deployed.
ControlBee	Connectivity to EPSU platform to display results to the beekeeper. e.g. REST API to be exposed.
ControlBee ControlUnit	IP/WAN connection via 2G/3G/LTE CAT-M1. Communication with sensors in local wireless network in ISM 868MHz band. Network capacity up to 100 sensors.
ControlBee Hive Sensor	Communication with the central unit in a local wireless network in the ISM 868MHz band. Wireless range up to 200 meters.
ControlBee Scale	Communication with the central unit in a local wireless network in the ISM 868MHz band. Wireless range up to 100 meters.
siloNET	Mobile network access.

15 Annex F - List of DEMETER Data Sources

This section contains a list of all data sources that have been named by the pilots and pilot partners.

15.1 Tragsa-Mega and OdinS-Smart Agriculture

Data Source Mega		
Data Short Description	The information is available through a SOAP and REST API for integrating with other services.	
Dataset Type		
Purpose in Pilot		
Dataset Owner	Irrigation Community of Cartagena and Left side of Porma River	
Dataset Provider	Tragsa and OdinS	
Access License		
Access rights for DEMETER		
Dataset Access	API REST and SOAP and API REST based on NGSI, NGSI-LD	
Version		
Volume		
Velocity	It depends on the server where the mega coordinator is deployed	
Variety	It can be as varied as everything specified in ISO 21622 and NGSI, NGSI-LD	
Veracity	It reflects the information transmitted by the control systems.	
Validity	It reflects the information transmitted by the control systems.	
Volatility	The information is stored in a database.	
Data format	JSON, JSON based on NGSIv2 format, or XML	
Encryption	Not yet	
Data structure description	JSON, JSON based on NGSIv2 format, or XML	
For unusual format, tool to read it	Provide link	
Remote accessibility	Yes/No	Yes
	Protocol	REST, REST via NGSIv2, or SOAP
	Message format	JSON, XML

Data Source Mega		
	Pull/Push	Pull, push Publish/Subscribe and query methods
	Provided interface	
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	
	Agent development requirements	
	Usable software API on device	
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	Actions triggered
Data Sample link		

15.2 FADN - Farm Accountancy Data Network

FADN (Farm Accountancy Data Network)	
Data Short Description	FADN Linked Dataset transformed from the official public database (in CSV format), which includes links to other open EU datasets like NUTS (Nomenclature of Territorial Units for Statistics) ,
Dataset Type	Linked Data (generated from source CSV files)
Purpose in Pilot	primary database for the pilot's benchmarking
Dataset Owner	European Commission / The Institute of Agricultural and Food Economics - National Research Institute (for Poland)
Dataset Provider	European Commission / The Institute of Agricultural and Food Economics - National Research Institute (for Poland). Linked Data is provided by PSNC
Access License	Open
Access rights for DEMETER	Open
Dataset Access	Linked Data endpoint https://foodie-cloud.org/sparql - graph(s): http://ec.europa.eu/agriculture/FADN/{FADN category}# Linked Data navigation: http://tiny.cc/9yshez source CSV files: https://ec.europa.eu/agriculture/rica/database/database_en.cfm
Version	Update: 29/May/2019
Spatial coverage	EU
Temporal coverage	from 1989 (for Poland from 2004)

<table>
<tr><th colspan="3">FADN (Farm Accountancy Data Network)</th></tr>
<tr><td>Resolution</td><td colspan="2">yearly</td></tr>
<tr><td>Volume</td><td colspan="2">~135 MB</td></tr>
<tr><td>Velocity</td><td colspan="2">unknown</td></tr>
<tr><td>Variety</td><td colspan="2">one structured source with Linked Data, transformed from the official source comprising of 15 tables (CSV files)</td></tr>
<tr><td>Veracity</td><td colspan="2">FADN data must be as sound and accurate as possible. The Liaison Agencies and the Commission take great care to ensure that any errors in FADN data are identified and corrected. The data is key for the pilot</td></tr>
<tr><td>Validity</td><td colspan="2">Yes</td></tr>
<tr><td>Volatility</td><td colspan="2">Forever, all data available (years) is needed</td></tr>
<tr><td>Data format</td><td colspan="2">RDF (from csv)</td></tr>
<tr><td>Encryption</td><td colspan="2">No</td></tr>
<tr><td>Data structure description</td><td colspan="2">RDF data represented using the Data Cube vocabulary: https://www.w3.org/TR/vocab-data-cube/, including all the code lists used in the source CSV files described in https://ec.europa.eu/agriculture/rica/diffusion_en.cfm</td></tr>
<tr><td>For unusual format, tool to read it</td><td colspan="2">Linked Data endpoint: https://www.foodie-cloud.org/sparql
Linked Data navigation: http://tiny.cc/9yshez
Website (source):
https://ec.europa.eu/agriculture/rica/database/database_en.cfm</td></tr>
<tr><td rowspan="5">Remote accessibility</td><td>Yes</td><td></td></tr>
<tr><td>Protocol</td><td>SPARQL</td></tr>
<tr><td>Message format</td><td>RDF, JSON, XML</td></tr>
<tr><td>Pull/Push</td><td>Pull</td></tr>
<tr><td>Provided interface</td><td>https://www.foodie-cloud.org/sparql (graph(s):
http://ec.europa.eu/agriculture/FADN/{FADN category}#)</td></tr>
<tr><td rowspan="3">If data is not yet accessible, how can they be retrieved?</td><td>Describe the architecture and where an agent can be deployed</td><td>Data is accessible, and can be accessed by other systems like the EPSU database backend</td></tr>
<tr><td>Agent development requirements</td><td>No</td></tr>
<tr><td>Usable software API on device</td><td>No</td></tr>
</table>

FADN (Farm Accountancy Data Network)		
Dataset generation	Was the data monitored in a system with real users?	Yes, FADN dataset is collected via trained staff and validated via Research Institute
	If no, how the data has been generated?	
Sample of data	http://tiny.cc/oushez	

15.3 Animal identification, rest and wellbeing, lameness detection

Animal identification, rest and wellbeing, lameness detection		
Data Short Description	Data (animal identification, rest and wellbeing, lameness detection) comes from AFIACTII sensors through an export procedure in CSV format.	
Dataset Type	CSV	
Purpose in Pilot	The monitoring of animal behaviour is strongly linked to the milk yield production. Furthermore, it provides information on animal health (also interesting for consumer awareness)	
Dataset Owner	Maccarese	
Dataset Provider	Afimilk Solutions (AfiActII)	
Access License	Maccarese	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	AfiAct version II	
Spatial coverage	NA	
Temporal coverage	Real time: 24/7 wireless reading	
Resolution	NA	
Volume	The data volume can change based on the type of data and on the period of service	
Velocity	Every 15 minutes (user configurable), AfiAct II sends updated activity data to the AfiAct software for analysis.	
Variety	Semi-structured animal identification, rest and wellbeing, lameness detection DATASET	
Veracity	Data after the analysis has no abnormalities, biases, or noise	
Validity	The data is accurate for the purposes and intended use	
Volatility	This data doesn't have an expiry date	
Data format	CSV	
Encryption	The data isn't encrypted	
Data structure description	to be defined	
Remote accessibility	No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	NA
	Message format	NA
	Pull/Push	NA
	Provided interface	NA

Animal identification, rest and wellbeing, lameness detection		
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

15.4 Rumination, eating habits and respiration monitoring

Rumination, eating habits and respiration monitoring		
Data Short Description	Data (rumination, eating habits and respiration monitoring) comes from the wearable device AfiCollar[9]	
Dataset Type	CSV	
Purpose in Pilot	The monitoring of animal rumination is strongly linked to the milk yield production. Furthermore, it provides information on animal health (also interesting for consumer awareness)	
Dataset Owner	Maccarese	
Dataset Provider	Afimilk Solutions (AfiCollar)	
Access License	NA	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	NA	
Spatial coverage	NA	
Temporal coverage	NA	
Resolution	NA	
Volume	The data volume can change based on the type of data and on the period of service	
Velocity	NA	
Variety	Semi-structural animal rumination and animal eating DATASET	
Veracity	The produced data after the analysis has no abnormalities, biases, or noise.	
Validity	The data is accurate for the purposes and intended use	
Volatility	This data doesn't have an expiry date.	
Data format	CSV Comma-separated values	
Encryption	The data isn't encrypted	
Data structure description	To be defined	
Remote accessibility	No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	
	Message format	NA
	Pull/Push	NA
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	NA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

9 https://www.afimilk.com/

15.5 Animal temperature

Animal temperature		
Data Short Description	Data (animal temperature) comes from the Data Log rectal control	
Dataset Type	CSV	
Purpose in Pilot	Animal temperature is linked to animal health	
Dataset Owner	Maccarese	
Dataset Provider	Datalog	
Access License	NA	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	NA	
Spatial coverage	NA	
Temporal coverage	NA	
Resolution	NA	
Volume	The data volume can change based on the type of data and on the period of service.	
Velocity	NA	
Variety	Semi-structured animal health DATASET	
Veracity	Data after the analysis has no abnormalities, biases, or noise	
Validity	The data is accurate for the purposes and intended use	
Volatility	This data doesn’t have an expiry date	
Data format	CSV	
Encryption	The data isn’t encrypted	
Data structure description	To be defined	
Remote accessibility	No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	NA
	Message format	NA
	Pull/Push	NA
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	NA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

15.6 Milk Quality

Milk quality		
Data Short Description	Data (milk quality) comes from Afilab allowing a quality control on milk quality from the single animal.	
Dataset Type	CSV	
Purpose in Pilot	The purpose within the pilot is to maintain high level of milk quality (indeed increasing the farmers yields and income). Within the pilot a milk separator (AfiLab) will be applied to the lacting machine in order to analyse and differentiate the high-quality product from the lower one.	
Dataset Owner	Maccarese	
Dataset Provider	AfiMilk Solutions (Afilab)	
Access License	NA	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	NA	
Spatial coverage	NA	
Temporal coverage	NA	
Resolution	NA	
Volume	The data volume can change based on the type of data and on the period of service	
Velocity	NA	
Variety	Semi-structured quality of milk DATASET	
Veracity	Data after the analysis has no abnormalities, biases, or noise	
Validity	The data is accurate for the purposes and intended use	
Volatility	This data doesn’t have an expiry date	
Data format	CSV	
Encryption	The data isn’t encrypted	
Data structure description	CSV file … to be defined	
For unusual format, tool to read it	NA	
Remote accessibility	No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	NA
	Message format	NA
	Pull/Push	NA
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	DNA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

15.7 Milk Composition

Milk composition		
Data Short Description	Milk composition analysis and related milk quality (in terms of payment) comes from automatic lactating device.	
Dataset Type	CSV	
Purpose in Pilot	The purpose is to allow a fully automatic solution for milk composition analysis for payment and dairy herd improvement.	
Dataset Owner	Latte Sano	
Dataset Provider	GiroTech Solutions (Milko Box MKII)	
Access License	NA	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	MKII HP	
Spatial coverage	NA	
Temporal coverage	NA	
Resolution	NA	
Volume	NA	
Velocity	NA	
Variety	Semi-structured milk composition analysis DATASET	
Veracity	The produced data after the analysis has no abnormalities, biases, or noise	
Validity	The data is accurate for the purposes and intended use	
Volatility	This data doesn't have an expiry date	
Data format	CSV	
Encryption	The data isn't encrypted	
Data structure description	NA	
Remote accessibility	Yes/No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	NA
	Message format	NA
	Pull/Push	NA
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	NA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

15.8 Characteristics of milk collected

Characteristics of milk collected		
Data Short Description	Data (characteristics of milk collected) come from MilkoScan FTIR.	
Dataset Type	CSV	
Purpose in Pilot	The purpose is to optimize the daily samples analysis collection.	
Dataset Owner	Latte Sano	
Dataset Provider	FOSS Solutions (MilkoScan FTIR)	
Access License	NA	
Access rights for DEMETER	Internet	
Dataset Access	Available on-premises by standalone software application through specific user interfaces	
Version	FT1	
Spatial coverage	NA	
Temporal coverage	NA	
Resolution	NA	
Volume	NA	
Velocity	NA	
Variety	Semi-structured characteristics of milk DATASET	
Veracity	The produced data after the analysis has no abnormalities, biases, or noise	
Validity	The data is accurate for the purposes and intended use if instrument calibration is appropriate	
Volatility	This data doesn’t have an expiry date	
Data format	CSV	
Encryption	The data isn’t encrypted	
Data structure description	NA	
For unusual format, tool to read it	NA	
Remote accessibility	No	Data is generated by not open proprietary systems, not accessible via API interfaces. A specific procedure exports these data in CSV format, through the interface applications provided by the software manufacturer.
	Protocol	NA
	Message format	NA
	Pull/Push	NA
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	NA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	To be defined	

15.9 Engine and After treatment sensor Data

Engine and After treatment sensor Data - 1		
Data Short Description	Sensor Data for example from CAN-Bus	
Dataset Type	File	
Purpose in Pilot	To Monitor engine and after treatment functionality	
Dataset Owner	Farmer	
Dataset Provider	Farmer	
Access License	Access is granted for JD by farmer	
Access rights for DEMETER	Contract between farmer and 3rd party is necessary	
Dataset Access	Not yet defined – right now only recent data can be monitored manually	
Version	Depending on status and type of machine	
Spatial coverage	Not relevant	
Temporal coverage	Not yet monitored – Goal: permanent	
Resolution	Depending on different Sensors and legislative regulations	
Volume	Depending on system which will be installed to monitor data	
Velocity	Depending on system which will be installed to monitor data	
Variety	depending on system and data to be analysed – different sensors for a variety of measurements; data formats are probably the same	
Veracity	depending on sensor and environmental influences	
Validity	some sensors deliver only valid information in operation conditions. Accuracy of sensors is pre-defined	
Volatility	data is over written constantly at the moment	
Data format	needs to be analysed	
Encryption	no	
Data structure description	to be defined	
For unusual format, tool to read it	to be analysed	
Remote accessibility	Yes/No	no
	Protocol	-
	Message format	-
	Pull/Push	-
	Provided interface	-
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	deploy agent at sensor data processing unit
	Agent development requirements	to be defined
	Usable software API on device	to be defined
Dataset generation	Was the data monitored in a system with real users?	Yes, on test bench purposes
	If no, how the data has been generated?	-
Sample of data	will follow	

15.10 GPS Positional Data of agricultural machinery

#1: GPS Positional Data of agricultural machinery		
Data Short Description	GPS Tracking Data	
Dataset Type	Positional Geodata, Geo-Coordinates	
Purpose in Pilot	Determination of machinery position	
Dataset Owner	m2Xpert	
Dataset Provider	m2Xpert and Farmers under supervision of John Deere	
Access License	TBD	
Access rights for DEMETER	TBD	
Dataset Access		
Version		
Spatial coverage	7 Fields in this Pilot. Mobile communications network required.	
Temporal coverage	During relevant phases of agricultural processes.	
Resolution	TBD	
Volume	TBD	
Velocity	TBD	
Variety	Structured only	
Veracity	Noise can occur through gaps in transmission of positional data due to mobile communications network outages	
Validity	Measurements have very small errors, acceptable for operational use	
Volatility	TBD	
Data format	Proprietary Base64-encoded format	
Encryption	No	
Data structure description	• Tracker ID • Timestamp • Longitude • Latitude • Energy Level of Tracking Device	
For unusual format, tool to read it		
Remote accessibility	No	TBD
	Protocol	
	Message format	
	Pull/Push	Push
	Provided interface	
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	TBD
	Agent development requirements	
	Usable software API on device	No
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data		

15.11 Operation Center

#2: Operation Center	
Data Short Description	- Field Boundaries: Shape, size

#2: Operation Center		
	- Fuel Map: Fuel consumption with geo references, machine and which fuel, total time of the job - As applied map: amount of fertilizer with geo references, machine, total time of the job and which fertilizer (one map per measurement/operation) - Machine: type of machine, machine ID	
Dataset Type	Geometry file	
Purpose in Pilot	Information to develop job cost model	
Dataset Owner	Farmers	
Dataset Provider	Farmer	
Access License	Contract with John Deere to use the data	
Access rights for DEMETER	There is no contract available to share that data. They have to be asked for that project. JD is the only party with direct contact to the farmers.	
Dataset Access	JD: Direct access to the Operation Center account for the farmer.	
Version	- (cloud solution)	
Spatial coverage	Focus on 7 German pilot farms	
Temporal coverage	Depends on the farms, e.g. 2-5 years available	
Resolution	Depends on e.g. the machinery size (swath width). Usually, the measurement is done several times per second and that information is aggregated every several seconds.	
Volume	TBD	
Velocity	Depends on the connectivity	
Variety	Structured and unstructured data (see for example the description)	
Veracity	There might be some data quality issues	
Validity	There might be some data quality issues	
Volatility	Storing time depends on the contract. No change on historical data.	
Data format	Shape file, text	
Encryption	Not encrypted if you have access to the data (JD)	
Data structure description	• Geo coordination • Time • Amount of Application • More tbd.	
For unusual format, tool to read it	Provide link	
Remote accessibility	Yes (only for John Deere) No (for others)	
	Protocol	-
	Message format	-
	Pull/Push	-
	Provided interface	-
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	-(JD will provide the data manually)
	Agent development requirements	-(JD will provide the data manually)
	Usable software API on device	-(JD will provide the data manually)
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data	-	

15.12 DWD Weather Data

#3: DWD Weather Data		
Data Short Description	Weather data for circumstance determination: - Temperature, solar radiation, wind, precipitation, … per area and time	
Dataset Type	Structured Weather data	
Purpose in Pilot	Determination of circumstantial information	
Dataset Owner	John Deere; publicly available web-sources (DWD)	
Dataset Provider	John Deere; publicly available web-sources (DWD)	
Access License	TBD; for open source data no access needed	
Access rights for DEMETER	TBD; for open source data no access rights needed	
Dataset Access		
Version	Recent	
Spatial coverage	Germany, focus on 7 farms in this pilot JD: 1-2 farms	
Temporal coverage	Daily data from respecting year, focus on relevant phases of agricultural processes.	
Resolution	for precipitation: 1 km x 1 km; lower resolution for further parameters (TBD)	
Volume	TBD	
Velocity	TBD	
Variety	Structured only	
Veracity	High	
Validity	Data is interpolated from weather station information; therefore, divergences from field-specific weather condition cannot be avoided.	
Volatility	TBD	
Data format	precipitation (DWD): ASCII-file (ra-yymmdd) John Deere: csv-files	
Encryption	-	
Data structure description	• Position • Timestamp • Temperature • Air pressure • Precipitation data	
Remote accessibility	TBD	TBD
	Protocol	TBD
	Message format	TBD
	Pull/Push	Pull
	Provided interface	TBD
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	A written agreement to share John Deere-intern and farmer data with other stakeholders needs to be defined.
	Agent development requirements	TBD
	Usable software API on device	TBD
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data		

15.13 Maschinenring Verrechnungssätze Labour

#5: Maschinenring Verrechnungssätze Labour (or KTBL or Börsenpreise)		
Data Short Description	Regional prices for employees Euro per hour or per hectare Regional Machine costs Regional price for fertilizers	
Dataset Type	Text / csv	
Purpose in Pilot	Economical information for calculation of job cost	
Dataset Owner	Maschinenring / KTBL / TBD	
Dataset Provider	Open source	
Access License	-	
Access rights for DEMETER	-	
Dataset Access	Via Internet	
Version	Recent	
Spatial coverage	Germany	
Temporal coverage	TBD	
Resolution	Regional information	
Volume	TBD	
Velocity	TBD	
Variety	Unstructured	
Veracity	-	
Validity	-	
Volatility	TBD	
Data format	Text, csv	
Encryption	TBD	
Data structure description	-	
For unusual format, tool to read it	-	
Remote accessibility	Yes	
	Protocol	
	Message format	
	Pull/Push	
	Provided interface	
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	TBD
	Agent development requirements	TBD
	Usable software API on device	
Dataset generation	Was the data monitored in a system with real users?	
	If no, how the data has been generated?	
Sample of data		

15.14 Processed, staged and analyzed GPS data

#6: Processed, staged and analyzed GPS data	
Data Short Description	Processed GPS data
Dataset Type	Geo-Coordinates, Velocity
Purpose in Pilot	Analysis of machinery position and staging of data, combination of circumstantial data with tracking information

#6: Processed, staged and analyzed GPS data		
Dataset Owner	m2Xpert	
Dataset Provider	m2Xpert	
Access License	TBD	
Access rights for DEMETER	TBD	
Dataset Access		
Version		
Spatial coverage	See #1	
Temporal coverage	See #1	
Resolution	TBD	
Volume	TBD	
Velocity	TBD	
Variety	Structured and unstructured	
Veracity	See #1	
Validity	Measurements have very small errors, acceptable for operational use	
Volatility	TBD	
Data format	Variety of formats: JSON, GeoJSON, GeoXML etc.	
Encryption	Yes, HTTPS	
Data structure description	• Tracker ID • Timestamp • Longitude • Latitude • Velocity • Aggregation Information for Map data	
For unusual format, tool to read it		
Remote accessibility	Yes	
	Protocol	HTTPS
	Message format	JSON
	Pull/Push	Pull
	Provided interface	REST
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	TBD
	Agent development requirements	TBD
	Usable software API on device	Yes
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data		

15.15 Sentinel 2

Data Source Name and ID		
Data Short Description	Sentinel-2 Sentinel 2 A+B – L2A reflectance, NDVI, GNDVI LAI, NDMI, NMDI, SAVI, TCARI/OSAVI, WDRVI	
Dataset Type	Raster file downloaded from Web Service	
Purpose in Pilot		
Dataset Owner	ESA	
Dataset Provider	ESA	
Access License		
Access rights for DEMETER	TBD	
Dataset Access	https://sentinel.esa.int/web/sentinel/missions/sentinel-2/data-products	
Version	(if available)	
Spatial coverage	globe	
Temporal coverage	from 2015, every 5 days	
Resolution	10-20m2	
Volume	Raster file of 1GB per 100km2 in UTM/WGS84	
Velocity	on average every 4 days depending on latitude.	
Variety	L2A reflectance, NDVI, GNDVI LAI, NDMI, NMDI, SAVI, TCARI/OSAVI, WDRVI	
Veracity	Data are filtered from ESA.	
Validity	Data from satellite are valid according to remote sensing data	
Volatility	Data remain valid.	
Data format	GZIP with XML, JP2, HTML https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/data-formats	
Encryption	HTTPS in the webservice	
Data structure description	Georeferenced raster data	
For unusual format, tool to read it	https://sentinel.esa.int/web/sentinel/missions/sentinel-2/data-products	
Remote accessibility	Yes	
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	XML
	Pull/Push	Pull
	Provided interface	NA
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	NA
	Agent development requirements	NA
	Usable software API on device	NA
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	NA
Sample of data	https://sentinel.esa.int/web/sentinel/missions/sentinel-2/data-products	

15.16 Meteoblue

Data Source Name and ID		
Data Short Description	Virtual weather station provider (Meteoblue)	
Dataset Type	API	
Purpose in Pilot		
Dataset Owner		
Dataset Provider	https://content.meteoblue.com/en/access-options/meteoblue-weather-api	
Access License	Commercial use with Creative Common License as in https://content.meteoblue.com/en/legal/commercial-non-commercial-use	
Access rights for DEMETER	TBD	
Dataset Access	Link to dataset (if open and available)	
Version	https://content.meteoblue.com/en/content/download/5503/228419/file/meteoblue_weather%20variables-documentation_EN_v06.pdf	
Spatial coverage	globe	
Temporal coverage		
Resolution		
Volume	1-2 MB / year	
Velocity	hourly update	
Variety	Structured (weather data)	
Veracity		
Validity		
Volatility		
Data format	JSON	
Encryption	HTTPS encrypted	
Data structure description	TBD	
For unusual format, tool to read it		
Remote accessibility	Yes/No	NO
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	json
	Pull/Push	Pull
	Provided interface	
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	The data should be available using the Agricolus API
	Agent development requirements	REST Client
	Usable software API on device	Yes (reference could be provided)
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	-
Sample of data	Provide a sample of data here or a link to it: TBD	

15.17 Sterile fruit fly information

Data Source Name and ID		
Data Short Description	Sterile fruit fly information	
Dataset Type	Web Service, API	
Purpose in Pilot	Make this information available	
Dataset Owner	Farmers	
Dataset Provider	Service provider	
Access License	TBD	
Access rights for DEMETER	Free for use	
Dataset Access	Soap	
Version		
Spatial coverage		
Temporal coverage		
Resolution		
Volume		
Velocity	Continuous	
Variety		
Veracity		
Validity	Yes	
Volatility	Data is stored in data base.	
Data format	json	
Encryption	https	
Data structure description	TBD	
For unusual format, tool to read it		
Remote accessibility	Yes/No	
	Protocol	
	Message format	
	Pull/Push	
	Provided interface	
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Data deployed in sensors
	Agent development requirements	TBD
	Usable software API on device	TBD
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data	TBD	

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Development Fund

15.18 Smartbow Animal Data

Data Source Name and ID		
Data Short Description	Data coming from Smartbow eartags Animal identification, rumination time, grazing time, activity and movement	
Dataset Type	File	
Purpose in Pilot	To examine the effectiveness of these cow behaviour characteristics as indicators of welfare and health of dairy cows	
Dataset Owner	TEAGASC	
Dataset Provider	ZOETIS	
Access License		
Access rights for DEMETER	For pilot activities purposes	
Dataset Access	Linked to dataset	
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution	Minute	
Volume	TBD	
Velocity	TBD	
Variety	2 sources of structured data 3 Animal ID: animal identification 4 Rumination time: length of time that animal ruminates for 5 Grazing time: length of time that animal grazes for 6 Activity and movement: number of steps taken and change in position of animal	
Veracity	The data will be meaningful to the problem being analysed but will show variation due to the individual animal effect?	
Validity	Yes, Smartbow have published on this topic?	
Volatility	Data will remain valid and can be stored indefinitely if required	
Data format	csv,	
Encryption	Zoetis may have their own encryption system.	
Data structure description	Aminal ID; Date; Group; Grazing time; Rumination time; Steps; Position;	
For unusual format, tool to read it	Not unusual format	
Remote accessibility	Yes Zoetis will provide access	
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	Protocol specific, JSON, XML (* use extra space if needed *)
	Pull/Push	Pull, push
	Provided interface	URI + interface specification (* use extra space if needed *)
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Zoetis will provide
	Agent development requirements	Programming language, framework
	Usable software API on device	Are there usable APIs? (if yes, describe them and add reference to the documentation)
Dataset generation	Was the data monitored in a system with real users?	Yes

Data Source Name and ID		
	If no, how the data has been generated?	Actions triggered /performed/simulated, how many of them, methodology
Sample of data	Provide a sample of data here or a link to it	

15.19 Milk Data

Data Source Name and ID		
Data Short Description	Milk data Milk yield, composition and conductivity	
Dataset Type	File,	
Purpose in Pilot	To correlate against welfare/health measures	
Dataset Owner	TEAGASC	
Dataset Provider	LELY	
Access License		
Access rights for DEMETER	For pilot activities purpose	
Dataset Access	Link to dataset	
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution	Every milking	
Volume	TBD	
Velocity	TBD	
Variety	Milk yield: amount of milk produced per animal Milk composition: composition (fat & protein) of milk produced per animal Milk conductivity: conductivity of milk produced per animal	
Veracity	The data will be meaningful to the problem being analysed but will show variation due to the individual animal effect	
Validity	YES – data collected by LELY on on-going basis is validated	
Volatility	Data will remain valid and can be stored indefinitely if re	
Data format	csv,	
Encryption	Lely may have their own encryption	
Data structure description	Animal ID; Date; Time; milk yield; milk fat; milk protein; milk conductivity	
For unusual format, tool to read it	Normal format	
Remote accessibility	Yes – lely do provide access	
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	Protocol specific, JSON, XML (* use extra space if needed *)
	Pull/Push	Pull, push
	Provided interface	URI + interface specification (* use extra space if needed *)
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	lely will provide access
	Agent development requirements	Programming language, framework
	Usable software API on device	Are there usable APIs? (if yes, describe them and add reference to the documentation)
Dataset generation	Was the data monitored in a system with real users?	Yes/No

Data Source Name and ID		
	If no, how the data has been generated?	Actions triggered /performed/simulated, how many of them, methodology
Sample of data	Provide a sample of data here or a link to it	

15.20 Sensor observations on Chicken Farms

Data Source Name and ID		
Data Short Description	Measurements acquired from sensors deployed on chicken farms	
Dataset Type	Web Service, API	
Purpose in Pilot	To run the service, evaluate ROI	
Dataset Owner	Farmer/service provider	
Dataset Provider	Service provider	
Access License	TBD	
Access rights for DEMETER	Free for use	
Dataset Access		
Version		
Spatial coverage	Farm buildings in Serbia, Slovenia and Georgia	
Temporal coverage	24/7	
Resolution		
Volume	3GB/month	
Velocity	Several times per day, except audio/video which is continuous	
Variety	6+ different types of sensors. JSON formatted.	
Veracity		
Validity	Yes	
Volatility	Data is stored permanently (12 months)	
Data format	JSON	
Encryption	HTTPS is used.	
Data structure description	TBD	
For unusual format, tool to read it		
Remote accessibility	Yes/No	Yes
	Protocol	MQTT, HTTPS
	Message format	JSON
	Pull/Push	Push
	Provided interface	TBD
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Data is pushed to poultryNET platform running on MS Azure. Interaction with data is done at that point.
	Agent development requirements	.NET/C#
	Usable software API on device	TBD
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data	TBD	

15.21 Sensor observations on vineyards/orchards

Data Source Name and ID		
Data Short Description	Measurements acquired from sensors deployed at vineyards/orchards	
Dataset Type	Web Service, API	
Purpose in Pilot	To run the service, evaluate ROI	
Dataset Owner	Farmer/service provider	
Dataset Provider	Service provider	
Access License	TBD	
Access rights for DEMETER	Free for use	
Dataset Access		
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution		
Volume	3GB/month	
Velocity	Continuous	
Variety		
Veracity		
Validity	Yes	
Volatility	Data is stored permanently (12 months)	
Data format	JSON	
Encryption	HTTPS is used.	
Data structure description	TBD	
For unusual format, tool to read it		
Remote accessibility	Yes/No	Yes
	Protocol	MQTT, HTTPS
	Message format	JSON
	Pull/Push	Push
	Provided interface	TBD
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Data is pushed to agroNET platform running on MS Azure. Interaction with data is done at that point.
	Agent development requirements	.NET/C#
	Usable software API on device	TBD
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data	TBD	

15.22 Quality information pastries production

Data Source Name and ID: Quality information bakery production: DS-52-3-UPM-1		
Data Short Description	Quality information pastries production	
Dataset Type	Web Service, API	
Purpose in Pilot	Make this information available to other parties in the supply chain	
Dataset Owner	Food producer	
Dataset Provider	Service provider	
Access License	TBD	
Access rights for DEMETER	Free for use	
Dataset Access	API REST	
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution		
Volume	Relatively low (MB/month)	
Velocity	Continuous	
Variety		
Veracity		
Validity	Yes	
Volatility	Data is stored permanently (12 months)	
Data format	JSON	
Encryption	HTTPS is used.	
Data structure description	TBD	
For unusual format, tool to read it		
Remote accessibility	Yes/No	Yes
	Protocol	MQTT, HTTPS
	Message format	JSON
	Pull/Push	Pull
	Provided interface	TBD
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Data is pushed from the production platform, interaction with data is done at that point.
	Agent development requirements	TBD
	Usable software API on device	TBD
Dataset generation	Was the data monitored in a system with real users?	Yes
	If no, how the data has been generated?	
Sample of data	TBD	