D3.1 Pilot Plan
&
Evaluation Methodology

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Table 1 List of abbreviations and acronyms

List of Abbreviations and Acronyms	
ADS(s)	Agricultural Digital Solution(s)
AI/ML	Artificial Intelligence/ Machine Learning
EC	European Commission
EU	European Union
KPI	Key Performance Indicators
ToC	Table of Contents
CAP	Common Agricultural Policy
SME(s)	Small and medium-sized enterprises
OS	Open Source
WP	Work Package
SIP(s)	Sustainable Innovation Pilot(s)
DSS	Decision Support System
FMIS	Farm Management Information Systems

Executive Summary

OpenAgri strategically aligns its endeavours across 14 SIPs, with an emphasis on open-source and open-hardware ADSs. This approach fosters the co-creation of digital solutions that are specifically designed to address the unique challenges and needs of diverse agricultural practices across Europe. The initial phase involves 5 core SIPs, set to commence immediately, while an additional 9 SIPs will be introduced through an Open Call, aiming to broaden the technological scope and geographic coverage.

The OpenAgri initiative is particularly geared towards enhancing digital adoption in agriculture, with a strong focus on regions and farming communities that currently exhibit low levels of digital engagement. The project intends to deploy and validate ADSs across multiple agricultural contexts—spanning various crops and livestock—to ensure extensive applicability and scalability. These ADSs are crafted to support farms of all sizes, emphasizing in SMEs, with solutions that aim to improve economic viability, reduce environmental impact, and boost overall productivity. Key areas of focus within the OpenAgri SIPs include optimizing resource use through advanced decision-support tools, enhancing sustainability practices, and facilitating compliance with the European Green Deal's agricultural mandates. For example, ADSs under development include systems for precision irrigation, disease detection in crops, and animal welfare monitoring, all designed to operate effectively even in remote areas with limited connectivity.

Each SIP is designed to co-create and pilot two configurations of the same ADS—one cloud-based and the other a mixed or edge-based model—to rigorously assess their performance across various dimensions: effectiveness in agricultural scenarios, efficiency of computing resources, use of standards, and adaptability to regional and socio-economic conditions. This dual approach is aimed at identifying the most suitable digital agriculture solutions that can operate under the unique constraints and opportunities presented by different farming environments, particularly focusing on areas with low digital adoption.

Deliverable D3.1 "Pilot Plan & Evaluation Methodology" encapsulates the strategic blueprint and comparative frameworks that govern the implementation and testing activities of OpenAgri's 5 core SIPs as defined under WP3 "OpenAgri Pilots and Dual Comparison of ADS" in Task 3.1 " Pilot Plan and Evaluation Methodology ". This document is instrumental in outlining the structured approach that OpenAgri will adopt to facilitate the development, deployment, evaluation and dual comparison of ADSs in each SIP.

The core of this document is the SIP execution plans which offer a detailed roadmap for the successful implementation of the SIPs. They specify the operational and testing procedures for each ADS, defining for each SIP the exact areas of deployment, a schedule for piloting, responsibilities and tasks of the providers, end users and all involved actors, reporting mechanisms and evaluation criteria. Additionally, it presents the evaluation methodology with a set of comparison metrics that measure agronomic performance, efficiency of computing resources, use of standards and adaptability to regional and socio-economic conditions providing a robust comparative analysis of the cloud and edge implementations of each ADS.

To facilitate smooth operation and early problem identification, a streamlined monitoring and coordination procedures will be put in place. Those procedures emphasize efficiency and minimal bureaucracy to allow SIPs to focus on their primary objectives, supported by regular progress reports and meetings to tackle any arising challenges and ensure the projects remain on track towards achieving sustainable innovation, collaboration, and effective management.

In summary, D3.1 provides a comprehensive roadmap for the operational execution and evaluation of ADSs within OpenAgri. It sets the stage for transformative impacts in European agriculture by systematically testing and validating digital solutions that enhance productivity, sustainability, and resilience across the continent's diverse agricultural landscapes.

1. Introduction

1.1. Project Summary

OpenAgri, a Horizon Europe project funded by the EU, is dedicated to empowering farmers through the provision of free, OS tools that are designed to operate effectively even in remote locations with limited network connectivity. Through its 14 SIPs, the project serves as a bridge connecting farmers to cutting-edge technologies, thereby narrowing the gap between rural and urban communities. This inclusive approach not only enhances access to essential tools but also contributes to a more prosperous and equitable future for all stakeholders involved. OpenAgri will follow a systematic comparative approach to pilot and compare the performance of edge, cloud and mixed ADSs along several socio-economic and environmental parameters. By addressing key challenges in the agricultural sector, including issues related to accessibility, performance, and sustainability of digital farming tools, OpenAgri is paving the way for a more resilient and efficient agricultural ecosystem.

1.2. Document Scope

WP3 through T3.1 aims to monitor the 14 SIPs, specifically 5 core SIPs and 9 additional SIPs by an Open Call, from the beginning of their core piloting activities [M1 for core SIPs and M22 for the additional SIPs] to ensure their smooth operation. These efforts demonstrate a commitment to efficient and effective operation of the SIPs towards sustainable development. Towards these efforts of SIPs monitoring, D3.1 includes for each SIP an execution plan defining the exact areas of deployment, a schedule for piloting, responsibilities and tasks of the providers, end users and all involved actors. Additionally, it describes the evaluation and comparison protocols that will be used to assess and compare the performance of edge, cloud and mixed model-based ADSs according to their effectiveness, efficiency and energy performance under consideration of various biogeographic and socio-economic framing conditions at farm and farm community level at regional and national scale. Moreover, as T3.1 aims to build a basis for the upcoming T3.3 related to pilot trials and user testing, D3.1 describes the procedures for piloting, reporting, troubleshooting and decision-making mechanisms which will be used during the pilot trials to ensure the smooth and successful operation of the SIPs.

1.3. Document Structure

This document is structured into several chapters:

Chapter 1 provides a brief introduction to the OpenAgri project, as well as the objectives of this deliverable;

Chapter 2 explains the background and the general objectives of the OpenAgri project and presents the methodology that will be used to assess and compare the performance of edge, cloud and mixed model-based ADSs in each SIP;

Chapter 3 describes all the procedures with their associated documents for piloting, reporting, troubleshooting and decision-making mechanisms;

Chapter 4 provides the SIP Execution Plans;

Chapter 5 brings the document's conclusions;

Annexes include the various templates presented in the deliverable.

2. Project's Background and link to SIPs

2.1. The project's background and approach

Over the last decade, there has been a significant rise in interest and investment in data and digital technologies in agriculture. ADSs are viewed as a major opportunity to enhance the sustainability and competitiveness of the agricultural sector by increasing food production, reducing costs, and minimizing the environmental impact of production. The EC anticipates that widespread adoption of digital technologies will help achieve the Green Deal's sustainability goals and facilitate CAP reporting obligations. However, despite significant efforts and resources spent, there remains a notable "gap" between the available ADSs in the market and their actual adoption and use by farmers in the EU. On the one hand, ADSs are typically expensive and not economically beneficial for small farmers, as they are designed for large-scale operations. Moreover, farmers distrust ADSs due to data misuse concerns, lack of algorithm transparency, and vendor lock-in risks, exacerbated by big tech companies entering the market. Furthermore, poor network connectivity in rural areas significantly impacts ADS performance, creating major challenges for remote farms.

OS software and hardware could address these issues by lowering ADS prices and enhancing transparency, thereby increasing trust. The success of OS depends on the community defining requirements, developing, and supporting components. In the case of AgriTech, although there have been some attempts by many organizations and communities, critical mass has yet to be achieved, partly due to the specificities of the Agri-Food sector compared to other industries. Another critical dimension for the successful adoption of OS in agriculture is the need to find suitable collaborative business models, to make it realistic for AgTech SMEs to create, share and reuse OS components, reaping the expected benefits without losing part of their business.

The adoption of edge computing solutions could help overcome problems with weak connectivity, allowing the use of ADSs in remote areas. However, these solutions usually perform less well, and have special requirements related to energy consumption, unlike cloud-based solutions which have access to more computing power, more data and continuously evolving AI models. Tailored OS ADSs that can function in the cloud, on the edge, or through mixed models are needed, suitable for various biogeographic and socio-economic contexts at different scales.

The OpenAgri project aims to democratize digital farming by developing and deploying innovative, cost-effective, energy-efficient OS software and open hardware-based ADSs that perform well even in remote areas with weak connectivity. This will be achieved by involving farmers and farm advisors in participatory prototyping activities inspired by the makerspaces approach to co-create OS and open hardware ADSs that address practical problems. Additionally, access will be provided to reusable OS software services that support edge and mixed computing modes, along with a "sociotechnical infrastructure".

OpenAgri will use a multi-actor approach, involving farmers, ADSs providers, farm advisors, scientists, and other AKIS actors in 5 core SIPs initially, followed by 9 additional SIPs from an Open Call. These SIPs will adopt new technologies in different crop/livestock types, covering at least ten countries across Europe. The SIPs will be guided in co-creating and piloting cloud, and edge/mixed based ADSs, addressing significant challenges in crop production and livestock management. OpenAgri will follow a systematic comparative approach to pilot and compare the performance of cloud and edge/ mixed based ADSs along several socio-economic and environmental parameters. Finally, taking advantage of a comprehensive analysis of the European agriculture sector and SIP results, OpenAgri will develop a Decision Support Tool to help policymakers, public authorities, farmers, and farm advisors select the best possible ADSs (cloud, edge, or mixed) for any given set of conditions.

2.2. Overview of the SIPs

In the context of OpenAgri, a series of SIPs will be launched in order to co-develop and test OS based ADSs following a dual and comparative approach. Each SIP will co-create 2 ADS, a cloud-based and an edge or mixed model-based and compare their performance in terms of effectiveness, efficiency, and energy performance. Through a careful selection process, a heterogeneous set of 5 SIPs has been defined, including a variety of solutions, sectors, countries and underlying conditions:

- Agri-food sectors: SIPs covering arable, fruit, vegetables, and livestock, while SIP5 is cross-sectoral.
- Countries: SIPs take place in Belgium, Cyprus, France, Greece, and Poland.
- Real-life needs: SIPs cover different sector needs like the reduction of production costs, input consumption and climate footprint, or an increase in animal welfare. All SIPs aim to reduce the farmers' administrative burden.
- Technologies: Machinery with Variable Rate Application (VRA), Unmanned aerial vehicles (UAVs), Internet of Things (IoT), Earth Observation (EO), near infrared (NIR) sensors, AI/ML, LoRaWAN, RFID UHF, DSS, BioElectric chemical analysis sensors, etc.

Table 2 Overview of the 5 core OpenAgri SIPs

SIP No.	Description of SIP
SIP1: Fruit/Grapes - Greece	Focuses on vineyards, addressing the need for early disease detection and reduced pesticide use to meet Green Deal goals and minimize environmental footprint. This ADS is a camera-based machinery add-on system for visual scouting, crop monitoring, enabling disease detection, canopy density profiling, and yield measurement and forecasting. This portable, low-power system uses two sets of high-resolution RGB colour cameras, five high power LEDs (night-time operation). It is also equipped with a GPU-accelerated computer and an RTK-ready GPS to facilitate the creation of map representations for each of the ADS's functions.
SIP2: Livestock/Meat cow production - France	Addresses the challenge of monitoring livestock, particularly meat cows, grazing far from the farmhouse. The need is for a cost-effective solution to automatically track herds and monitor their activities, which, by identifying behavioural patterns, could quickly indicate potentially sick animals, even in areas with weak connectivity. The ADS utilizes RFID UHF technology to track water drinking patterns in conjunction with weather conditions to detect sickness. This system includes data loggers, and UHF ear tag for each animal. The RFID reader system will be also connected to a 4G/5G router so that data can be communicated remotely.
SIP3: Arable potatoes - Belgium	Focuses on addressing the challenge of detecting and managing the Colorado Potato Beetle infestation, aiming to maintain profitable and sustainable agricultural practices. The ADS employs a UAV with RGB cameras for rapid and accurate detection of areas affected by the beetle. Advanced AI algorithms create prescription maps that guide actions like VRA spraying, incorporating data from weather conditions and crop growth stages.
SIP4: Arable sugar beet and potatoes - Poland	Addresses the challenge of efficient irrigation aiming to reduce water use, support plant growth, and minimize diseases caused by excessive soil moisture. The ADS features a smart irrigation controller connected to irrigation valves and integrates with soil moisture sensors and FMISs. It automates irrigation by optimizing water doses using data on the evapotranspiration, rainfall, water needs of plants, temperature effects and soil type, which will be obtained both from connected soil moisture sensors and from external datasets: weather stations, soil maps, weather forecasts and satellite data.
SIP5: Cross-sector in	Focuses on replacing chemical fertilizers with organic compost in the cultivation of vegetables like tomatoes, cucumbers, and lettuce. The goal is to reduce input costs, support organic production, and meet Green Deal targets. This ADS involves a low-cost,

vegetables - Cyprus	deploy-and-forget IoT-based for monitoring compost piles and provides a DSS that automates the labour-intensive process of maintaining compost piles. It uses LoRaWAN and LoRA linked sensors to monitor temperature, moisture, and pH levels. It also provides warnings for key events, while it enables the automation of mitigation actions. Additionally, a portable BioElectric-chemical analysis sensor (BELD) estimates the NPK content of compost samples on-site and in near-real-time.

In addition to these 5 cores SIPs another 9 SIPs will be selected by the OpenAgri Open Call, to cover more solutions, crops, countries, and conditions. All 14 SIPs will make use of the OpenAgri OS Services and interoperability mechanisms, and will create new OS results, to allow for maximum reproducibility and overall update of the project results.

2.3. Overview of the methodology

In the context of the SIPs, each one will develop two versions of the same ADS; one will be cloud-based, while the other will employ edge or mixed model-based technologies. This dual approach is crucial for conducting a comparative analysis that highlights the strengths and weaknesses of these technologies across various agricultural contexts.

Understanding the performance and impacts of ADS in real-world scenarios is of greatest importance. Therefore, the evaluation methodology has been structured based on four critical dimensions: 1) Effectiveness and Performance in Agriculture Scenarios, 2) Computing Resource Utilization and Energy Efficiency, 3) Use of Standards/Interoperability and Switchability, and 4) Regional and Socio-Economic Impacts. Each dimension is essential for a comprehensive assessment of the ADS under review, covering their capabilities, efficiencies, and broader impacts.

Through detailed analysis across these dimensions, the methodology aims to provide a holistic view of the functionalities and contributions of the ADS. This facilitates informed decision-making for future agricultural innovations. The subsequent sections will elaborate on each of these key dimensions for evaluation, laying out a comprehensive framework for the analysis. The evaluation metrics arising from these dimensions have been integrated into the execution plan of each SIP detailed in the subsection 'Evaluation & Comparison metrics'.

1. Effectiveness and Performance in Agriculture Scenarios

The effectiveness and performance of ADSs in agricultural scenarios are fundamental to their success. Evaluating these technologies involves a thorough assessment of their performance in the field, their operational precision, and their overall impact on farming efficiency and environmental sustainability. This evaluation considers both cloud-based and edge or mixed model-based ADSs across several key metrics. The key metrics for this evaluation include:

- **Technology Accuracy and Precision:** Assessing the performance, effectiveness, and accuracy of the technology's intended operations (Examples: disease detection accuracy, irrigation reduction).
- **Operational Efficiency and Time Savings:** Measuring improvements in operational speed and the reduction in time required for various tasks.
- **Cost Efficiency and Resource Optimisation:** Evaluating the cost savings, financial benefits, and optimization of resources facilitated by the technology.
- **Environmental and Sustainability Impact:** Determining the impact of the technology on environmental sustainability (Examples: reduction in chemical use, water conservation, carbon footprint reduction).

2. Computing Resource Utilisation and Energy Efficiency

Understanding the computing resource utilisation and energy efficiency of ADSs is crucial, particularly within the realm of sustainable agriculture. This dimension involves a comparison between cloud-based and edge or mixed model-based ADSs regarding their operational resource demands and energy consumption. The metrics for evaluating computing resource utilisation and energy efficiency include:

- Networking resources utilisation for data transmission for the two scenarios.
- Computing resources utilised for image processing in the two scenarios.
- Total energy consumed for data processing and data transmission.
- Total energy consumed for completing the farming operation.

3. Use of Standards/ Interoperability and Switchability

Standards, interoperability, and switchability are fundamental for the seamless integration and widespread adoption of ADSs. Compliance with standards and interoperability comes "with a price" as, for example, more computing/networking resources might be necessary for implementing semantically enriched data models and APIs. In this "Use of Standards / Interoperability and Switchability" evaluation metric it will be reported compliance with standards and interoperability for each tested approach (cloud vs mixed/edge). The evaluation will not be limited only in reporting the number of different standards used within the two approaches but will also provide a short qualitative analysis with regards to potential limitation and/or benefits introduced by each technical approach. The items described in following table will be reported and analysed for the cloud and for the mixed cloud/edge approach. An indicative score will escort the analysis denoting the overall efficiency of the implemented approach.

Overall, this dimension evaluates the adherence of ADSs to established standards and protocols, ensuring compatibility, and facilitating ease of data exchange.

The metrics for assessing standards, interoperability, and switchability include:

- Use of standardised network protocols for data communications (e.g. IoT protocols);
- Use of standardized data formats for data derived from hardware measurements;
- Use of standardized data formats for modelling/expressing farming practices/activities and recommendations generated by the ADS.

Based on the above standards the following Table 3 presents the metrics that will be used across all SIPs to evaluate and compare the cloud and the mixed/ edge-based ADS in each SIP under the 'Use of Standards' dimension.

Table 3 Overview of the 'Use of Standards' metrics

Metric	Analysis
Evaluation of data standards and file format types that are used for modelling the generated/ exchanged datasets.	The list will be accompanied by a short repot analysing the data modelling approaches (e.g. use of ontologies and semantics) and the respective implemented mechanism to achieve standardisation and interoperability (e.g. data parsers and translation scripts). The analysis will include the overall barriers/challenges for implementing the data standardisation approach and the actual (or potential) benefits.
Evaluation of networking/communication standards used for enabling interactions among the different modules of each solution.	The list and analysis are expected to include low level telecom protocols (e.g. 4G, WiFi, RF, Bluetooth) but also higher-level IoT protocols (e.g. MQTT, NB-IoT, LoRaWAN) A short repot will analyse the technical specification of the networking/communication standards used and the associated barriers and benefits.

Switchability capabilities of the piloted **software modules**.	The evaluation report/analysis will focus on the potential on reusing the software services in different context with the use of containerisation technologies (e.g. docker, kubernetes)
Switchability on farm data collections	The evaluation report will focus on the feasibility of retrieving data collections (e.g. training data sets, data logs with applied farming practices, properties of parcels) and reusing them with solution from different providers.
Switchability capabilities of the piloted **hardware modules**.	The evaluation report/analysis will focus on the potential on reusing the hardware services in different context (e.g. plug n play mechanisms, hardware protocols.

4. Regional and Socio-Economic Impacts

The dimension of regional and socio-economic impacts examines the broader effects of ADSs implementation. It covers the technological, cultural, and economic impacts within the specific contexts of the SIPs, offering insights into the real-world applicability and acceptance of ADSs. The evaluation considers socio-economic and regional-specific peculiarities in relation to the local context in which each SIP operates. The metrics for assessing the regional and socio-economic impacts include:

- **Implementation and Usage**: Assessing the initial expectations vs. the actual experience, duration of use, extent of use in the pilot.
- **Usability and Support:** Rating the ease of use and assessing the quality of technical support.
- **Suggestions for Improvement and Future Prospects**: Gathering recommendations for wider adoption and collecting advice for organizations considering the ADSs.
- **Cultural Perceptions and Data Trust Issues**: Measuring the resistance to change, the required digital skills, the alignment with innovation, the importance of data trust issues, the intention to share data, and the alignment with local cultural values regarding data privacy.
- **Infrastructure and Regional Opportunities/Limitations**: Evaluating the interference by field structures or formats and the compatibility with existing machinery and infrastructure.
- **Economic and Socio-Economic Impact**: Determining the contribution to economic growth, the impact on social inclusion and the digital divide.

Based on the metrics identified for assessing the regional and socio-economic impacts of ADSs, a targeted questionnaire was developed. This questionnaire will be used by each SIP and aims to collect feedback annually from the ADS users regarding both cloud and edge or mixed-based ADSs. By capturing insights into the effectiveness, challenges, and acceptance of these systems in various operational contexts, the questionnaire facilitates an in-depth evaluation of ADS's broader implications. The insights acquired from this process are essential for guiding future improvements and shaping adoption strategies. The questionnaire, designed to be completed for both the cloud and the edge or mixed ADS is as follows:

Table 4 Regional and Socio-Economic Impact Questionnaire

Regional and Socio-Economic Impact Questionnaire
a) How would you describe your initial expectations for the (Cloud, Edge/ Mixed) ADS? ☐ Exceeded expectations ☐ Met expectations ☐ Below expectations ☐ Far below expectations
b) How would you rate the ease of use of the (Cloud, Edge/ Mixed) ADS? ☐ Very easy to use

☐ Somewhat easy to use
☐ Neutral
☐ Somewhat difficult to use
☐ Very difficult to use

c) How has the complexity or simplicity of the (Cloud, Edge/ Mixed) ADS affected its adoption in your organization?
☐ Significantly influenced adoption rate
☐ Moderately influenced adoption rate
☐ Slightly influenced adoption rate
☐ Not influenced adoption rate

d) Would you recommend wider adoption of the (Cloud, Edge/ Mixed) ADS within your organization or sector?
☐ Definitely yes
☐ Probably yes
☐ Not sure
☐ Probably not
☐ Definitely not

e) How would you rate the willingness for adopting the (Cloud, Edge/ Mixed) ADS within your organization?
☐ Very high resistance
☐ High resistance
☐ Moderate resistance
☐ Low resistance
☐ No resistance

f) How would you rate the required level of digital skills for the (Cloud, Edge/ Mixed) ADS?
☐ Very high
☐ High
☐ Moderate
☐ Low
☐ Very low

g) Are you comfortable with the amount of data that leave the farm?
☐ Definitely yes
☐ Probably yes
☐ Not sure
☐ Probably not
☐ Definitely not

h) Are there any physical objects or structures in the field interfering with the (Cloud, Edge/ Mixed) ADS or the tasks performed (No/ Yes)
☐ No
☐ Yes
If yes please describe:
Answer

i) How compatible is the (Cloud, Edge/ Mixed) ADS with existing machinery and technology infrastructure in your operations?
☐ Highly compatible
☐ Mostly compatible

☐ Moderately compatible ☐ Barely compatible ☐ Not compatible
j) How has the (Cloud, Edge/Mixed) ADS contributed to economic growth within your region? ☐ Significantly contributed ☐ Moderately contributed ☐ Slightly contributed ☐ Not contributed
k) How has the utilization of (Cloud, Edge/Mixed) ADS addressed the digital gap in your region? ☐ Greatly reduced the digital gap ☐ Somewhat reduced the digital gap ☐ No significant impact on the digital gap ☐ Worsened the digital gap
l) Which ADS concept would you choose and why? What makes it the best fit for you? Answer:
m) What are your overall thoughts on the (Cloud, Edge/Mixed) ADS? Answer:

The first two dimensions 'Effectiveness and Performance in Agriculture Scenarios', and 'Computing Resource Utilization and Energy Efficiency' will be further elaborated within individual SIP plans. This tailored approach enables each SIP to adapt the evaluation criteria to its specific technological and operational nuances, ensuring a precise and context-sensitive assessment. In contrast, the dimensions of 'Use of Standards/Interoperability and Switchability', and 'Regional and Socio-Economic Impacts', will be uniformly applied across all SIPs as presented in the methodology. The uniform application of the standards dimension across all SIPs ensures that the foundational criteria such as data exchange protocols, interoperability benchmarks, and switchability mechanisms are consistently assessed, providing a standardized baseline for comparison. This is essential for gauging the effectiveness of integration and operational compatibility across varied technological ecosystems. Similarly, evaluating socio-economic impacts consistently across SIPs provides crucial insights into the broader implications of ADS implementations, highlighting commonalities and differences in regional adoption and the systemic effects on communities. By standardizing these dimensions, the methodology captures comprehensive, comparable data that can illuminate core trends and foster informed strategies for the widescale integration of agricultural technologies.

3. Procedures for piloting, reporting, troubleshooting and decision-making mechanisms

3.1. Monitoring and reporting framework

One of the main objectives of WP3 is to monitor the progress of the SIPs during two growing seasons as well as provide a comprehensive report of the evaluation outcomes at the end of each season. For this purpose, it is important to establish a SIP Monitoring and Reporting framework which will ensure the smooth operation of the SIPs by tracking their progress, detecting of any upcoming obstacles and challenges as well as support the evaluation process.

The framework will include three (3) mechanisms: a) the SIP Monthly Progress Report, b) the SIP Annual Evaluation Report and c) the SIP meetings.

3.1.1. SIP Monthly and Annual Progress Report

The SIP Monthly and Annual Progress Reports, outlined in Annexes 2 and 3 respectively, are essential tools designed to monitor and evaluate each SIP comprehensively. The reports are divided into three main sections: a) the **SIP Progress Report** provides a comprehensive overview, detailing objectives, key achievements, challenges encountered, and overall progress of various activities to give a clear picture of ongoing developments and any obstacles that may impact the project's trajectory, b) the **Key Results** section captures crucial outputs and outcomes from the SIP activities, including detailed analysis of key performance indicators such as the number of ADSs used, the development and utilization of OS software/hardware, and the engagement of actors in co-creation and piloting activities, aiming to quantify the achievements within the reporting period, c) the **Comparison Metrics** section evaluates the SIP across the four critical evaluation dimensions as outlined in the methodology.

Specifically for the **Comparison Metrics** section the "Effectiveness and Performance in Agriculture Scenarios" and the "Computing and Network Resources Utilization and Energy Efficiency" dimensions will be tracked on a monthly basis through the monthly report template to provide continuous feedback on operational effectiveness and technological efficiency, with comprehensive annual measurements to assess long-term trends and impacts. Meanwhile, the "Use of Standards/Interoperability and Switchability" and the "Regional and Socio-Economic Impacts" dimensions will be evaluated at the end of each season through the annual report template to ensure that the broader impacts and compliance with established standards are assessed in a holistic manner, reflecting the SIP's integration into larger agricultural and social contexts over the annual cycle. This structured approach not only facilitates detailed monitoring and immediate troubleshooting but also supports strategic decision-making by providing a layered understanding of both the immediate outcomes and broader impacts of the SIP activities. Through these reports, SIPs can maintain alignment with their objectives, adapt to emerging challenges, and strategically plan for future activities based on solid empirical evidence.

3.1.2. SIP meetings

The SIP leaders will be provided with a fixed schedule of meetings that they should attend throughout the whole project.

- **Bi-monthly meetings** between T3.3 Leader (AUA team) and the different SIP Leaders: The Bi-monthly meetings must be attended by all the different SIP leaders and will take place every two months starting from March 2025. The scope of the meetings is:
    1. Keeping intra- and inter-SIPs' interactivity.
    2. Assuring a periodic evaluation of the SIPs.

3. Solving problems during SIP implementations or evaluations, as well as seeking synergies of solutions among SIPs.
4. Ensuring the evaluation of the KPIs and the comparison metrics as expected through the bottom-up approach.
5. Exchanging information and experiences between all the SIPs.

- **Internal SIP meetings** between SIP Leader and partners inside each SIP: The frequency of the internal SIP meetings is determined by each SIP leader according to the needs during the project. Both the SIP leader and all the partners involved in the SIP must participate in this meeting. Nevertheless, the SIP leader could organize specific meetings with any of the partners to solve a specific issue. The scope of the meetings is:
    1. Carrying out the coordination of each SIP.
    2. Knowing and reporting the follow up and status of the activities.
    3. Reporting problems to the SIP leader for finding a solution on time or to inform the WP3 leader if necessary.
    4. Assuring constant KPIs evaluation for each SIP.

3.2. Communication and channels

Different aspects make it necessary to establish specific guidelines for the communication channels around the project. Among them, we can highlight the internationalisation level of the project, and the number of different members involved in the project. Therefore, the main communication channels used are specified below:

- Google Drive: Platform which will be used to share all the information related to the OpenAgri project between the members.
    - Table with information contact of partners, SIPs leaders and WPs leaders.
    - Specific folder for each SIP.
    - Templates to use for piloting, monitoring, and reporting the SIPs (SIP Execution Plan and monthly and Annual report templates).
    - Presentations shown in the meetings, as well as webinars or recorded meetings.
    - Other important documents and reports of the SIPs.

  In addition, it will be useful when it is necessary to collaborate on the production of documents. Creating different folders for each SIP, partners involved in each could open new google docs, sheets or slides to work together in the same documents, having access to all the shared documents and information.
- Google Meet, Microsoft Teams, Skype: Any kind of similar platform could be used for the majority of the aforementioned project meetings, due the impossibility of numerous physical meetings. The coordination and the setup of the meetings can be done using doodles or timesheets.
- Emails: It will be used for daily and frequent communications, as well for documentation and information exchange.

In addition, it is necessary to make clear that the overall information flow within the project will be ensured by the following means / guidelines:

- Activities like exchange of information, internal technical and business documents (i.e., meeting minutes), technical documentation generated by the project, notifications of relevant new publications, reports from external / bilateral meetings (if any), notifications of the consortium of any updates from the relevant standardization bodies, are foreseen to occur in electronic format via the project's web-based repository (google Drive) as well as by e-mail. For each document upload the consortium will be notified by email.

- Urgent correspondence over e-mail will be sent with a request for explicit acknowledgement and indicated in the title with “URGENT”.

Ordinary mail will be used for strictly formal correspondence, i.e., when executive signatures are required.

4. The OpenAgri SIPs

4.1. SIP Execution plans

WP3 under T3.1 is responsible to design and implement a comprehensive pilot plan for each SIP defining for each SIP: a) the exact areas of deployment, b) a schedule for piloting, as well as c) responsibilities and tasks of the providers, end users and all involved actors. Based on the above three parameters, T3.1 designed a SIP execution plan template including the following eight (8) sections:

1. **SIP General Information & SIP ADSs information** aims to provide a clear and brief overview for the SIP presenting the SIP Section.
2. **Participants involved** outlines key participant details for the SIP, including participant name and type, position in the value chain (e.g. farmer, tech provider), their role in the SIP, region/country and contact details.
3. **Co-created ADS & Data involved in the SIP** provides an overview of the ADSs, encompassing its architecture for both cloud-based and edge/mixed-based solutions. It details the OpenAgri OS services used, as well as the software and hardware developed, describing the current state of the ADSs (devices, operating systems, power sources, energy consumption). Additionally, it covers the types of data collected (category, data items, formats).
4. **Activities & Milestones** outlines the SIP activities, along with their goals, brief descriptions, participating individuals, and associated milestones.
5. **Dissemination & Demonstration activities** cover the SIP dissemination and demonstration activities, including brief descriptions, channel types, frequency, targeted groups, and materials used for dissemination.
6. **Evaluation & Comparison metrics** elaborates on specific ADS evaluation and comparison metrics selected for each SIP under the 'Effectiveness and performance in agriculture scenarios' and the 'Computing resource utilisation and energy efficiency' dimensions while also presenting a brief overview of the metrics used for the 'Use of standards / interoperability and switchability' dimension.
7. **Key results** provide details on KPIs, including descriptions, target values, any additional comments, and links to related dissemination activities.
8. **Risk management** shows risks identified within specific activities and proposed corresponding risk-mitigation measures.

The SIP Execution Plan template which was completed by each SIP leader in collaboration with partners from WP2 and WP3 can be found in ANNEX 1.

4.2. SIP1 Execution Plan

SIP name	SIP coordinator(s) Contact Info
SIP1 – Using Viewer device for visual scouting for disease detection, yield estimation, forecasting and pest management in vineyards in Greece	Giannis Avgoustakis ioavgous@edenlibrary.com

SIP GENERAL INFORMATION	
SIP sector(s)	Vineyards
Agri-food sector	Production
Geographical coverage (Country/ Region)	Tripoli/Greece Florina/Greece
SIP Partners	EDEN, AUA
Farmers & Advisors involved	Tselepos and Kyr-Gianni wineries
SIP Challenge (Need/Problem)	In the field of modern viticulture, particularly with notable Greek wineries like Kyr-Gianni and Tselepos known for their high-quality wines and innovative winemaking techniques, they are facing three main challenges. The first should be noted as **managing the logistics** of the winery for properly allocating the labour and farming equipment, optimising the supply chain for inventory management and planning the season's finances. Equally critical is the **early pest detection** aiming to identify and address these threats at the earliest stages to prevent widespread infestation in the vineyard. These wineries are recognized for **conducting up to 14 spraying sessions** in each cultivating season to prevent diseases. Therefore, it is essential to utilise variable spraying technology, which enables the application of varying rates of substances across different areas of a field, customised to their unique needs, instead of applying a uniform rate throughout. In addition, there is a need to optimise the overall energy and labour effort for scanning and performing the various farm practices.
ADS Overview	To address the identified challenges in these wineries, SIP1 will use an ADS named "Viewer", which is being developed and assembled by Eden Library (EDEN). The Viewer is a portable device that is attached to the front of the tractor designed for visually scouting vineyard production. This system is equipped with two sets of high-resolution RGB colour cameras for each canopy side and five high-power LEDs for night-time operation. Additionally, it is outfitted with an RTK-ready GPS allowing for the global georeferencing of camera streams, which facilitates the creation of map representations for each of the Viewer's functions. Equipped with a GPU-accelerated computer, the Viewer leverages AI vision technology to tackle the three primary challenges in wine production. For this SIP, the device's functionalities will be evaluated and utilized for **pest detection**, **canopy density profiling**—which provides essential information for variable rate spraying and it is sprayer agnostic—and **yield estimation**, predicting the wineries' total production based on the vineyard's phenological phase. All these metrics are fused in order to provide a metric for plant stress indicator, a metric valuable for properly monitor for the wine producer. The Viewer device can be operated from a dedicated **tablet** which gives the user all the necessary information about the device's diagnostics, start a new session or connect the Viewer in an available Wi-Fi network.
Other Data uses	The yield predictions help farmers plan their labour needs and logistics, maximising profit margins. The ADS is logging the "as-applied" spraying data facilitating the traceability of grape products and the treatments applied. Proper registration of chemical applications at individual farmers and member-states level, increases transparency and prevents frauds.

4.2.1. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**
Eden Library/SME	Technology Provider	SIP leader, ADS provider	Attica/Greece	Giannis Avgoustakis ioavgous@edenlibrary.com
Tselepos estate	Winery	End user	Tripoli/Greece	Giannis Avgoustakis
Kyr-Gianni estate	Winery	End user	Florina/Greece	Giannis Avgoustakis

4.2.2. Co-created ADS & Data involved in the SIP

ADS Description
The overview outlines three key functionalities to be tested for these wineries: detecting pests, estimating yields, and recommending spray actions based on canopy density analysis. All these metrics are fused in order to provide a metric for plant stress indicator, a metric valuable for properly monitoring the vineyard production. This SIP will explore two approaches, one using a cloud-based version of the ADS and one using a mixed-model version. In both versions, the Viewer will be mounted at the front of the tractor using a specially designed mounting solution.
Cloud-based ADS Architecture
In the cloud-based approach, the Viewer will be used for offline pest detection, yield estimation, and canopy profiling within vineyards, employing AI vision models. The strategy involves capturing images from both sides of the vineyard along with GPS coordinates, then uploading this data via a Wi-Fi-connected ADSL line. It must be noted that this device needs approximately **0.0133 gigabytes (GB) per metre** (133 gigabytes (GB) / hectare) of image data which will later be uploaded to a predefined GPU cloud node. Once uploaded, this data will enable us to train using manual annotation in a small subset of images (300 images) to train an AI model. This AI model will be further applied in the rest of the dataset and address the three identified functionalities (yield estimation, canopy profiling, and disease detection) through the use of advanced deep learning models like YOLO and Mask R-CNN. It must be noted that having the image data in an online GPU server, will enhance the complexity of YOLO and Mask R-CNN models that can be trained, thus give more accurate AI models and better results (metric used: mean Average Precision) but will also have slower detection responses (metric used: frames per second). By integrating detection data with GPS coordinates, we can generate detailed map overlays that encapsulate this information. For yield estimation and disease detection, the maps will be divided into square metre cells, each detailing the count of detected fruits and any identified diseases. Canopy characterization will also be detailed in these cells, indicating the canopy volume in cubic millimetres.

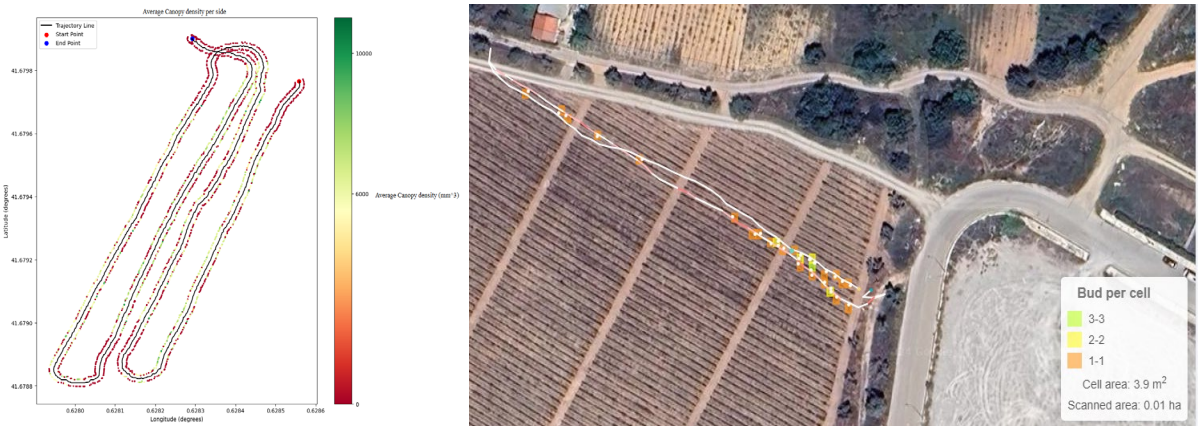


Figure 1 Demo images with examples of canopy profiling (left) and yield estimation (right) across various maps.

Maturity of the ADS	**Current TRL**	**TRL Goal [M36]**
	6	**7**

Mixed model-based ADS Architecture
In the mixed SIP approach, we will employ the same Viewer setup as described for the cloud case, aiming to fulfil the same three functionalities. The strategy for this approach is based on processing image streams **real time**, utilising pre-trained AI models (YOLO, Mask R-CNN) at average **0.002 GB per metre** (200 gigabytes (GB) / hectare), which

varies based on the desired **accuracy** of the model. It's important to emphasise that a data collection strategy must be implemented to train the AI models before the commencement of the first trial season. Since the Viewer uses pre-trained models, it can detect in real-time the specified functionalities during tractor operations and, upon session completion, upload only the metadata (no raw images) along with GPS coordinates via **cellular connectivity** to the **Eden Library's** server. The metadata will include the necessary information to generate a map representation incorporating the three functionalities, as outlined in the cloud-based approach. In more details, in the mixed (Cloud-edge) approach the Viewer will have the option to dynamically select among two pretrained image processing that already available in the local storage of the device:

The "Light Scouting" will allow to complete the scanning mission faster but will generate less accurate results requiring a relatively medium velocity of the tractor (e.g. 8 km/h).
The "Intense Scouting" will be more resource intensive in terms of processing and needed time to generate results and will require a lower velocity of the tractor (e.g. 4 km/h).

Captured Images will be processed in real time and upon the satisfaction of predefined logical rules expressed with the use of thresholds and conditions (e.g. canopy volume is lower than x cubic millimetres) it will be feasible to dynamically adapt the scanning process by selecting the image analysis approach available as a YOLO object detection model. A logical rule to be tested will dictate that upon the detection of a plant stress alert (with the use of the light model) an indication to the tractor operator will be rendered that a more resource intensive scanning needs to be realised. The "Viewer" module will then adapt accordingly and load the intense model pre-trained AI model (as a YOLO file) of higher accuracy which requires lower scanning speed (hence the velocity of the tractor needs to be reduced in 4 km/h).

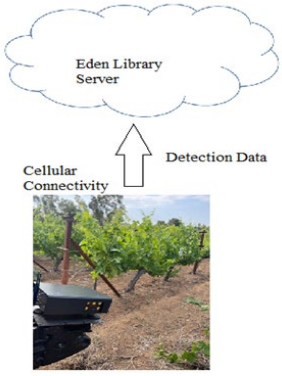


Figure 2 Mixed model-based Viewer architecture

Maturity of the ADS	Current TRL	TRL Goal [M36]
	7	8

OpenAgri OS services used

For the mixed/edge device and cloud approach the Viewer will be connected with the "Pest and Disease Management" OpenAgri OS service and using environmental data from the weather stations and using agronomic knowledge, the viewer will alert the user and to choose more accurate models regarding the Disease Detection.
For the mixed/edge device and cloud approach the Viewer will also be connected with the Digital Farm Calendar by sending the farmer activity, the parcel properties and the Viewer visual scouting functionality found (total diseases, total fruits counted, total canopy detected).
Data sharing will be assisted by the respective OpenAgri service, namely the "Interoperable data exchange and Access Control" service.

OS Software &/or Hardware developed

Significant portions of the collected data and pre-final versions of the image processing AI models, from both the mixed/edge device and cloud approach, will be freely available for reuse.

Current Design of the ADS

Devices/ Equipment	Viewer: a device equipped with high-resolution cameras and 5-LED arrays, for night-time operations if needed, each side, a GPU-computer and a GPS module. This device will be used for serving the yield estimation, measuring foliage density and disease detection in vineyards. Dedicated Tablet: This tablet, which comes with the Viewer, is essentially a regular tablet equipped with the EDEN application, allowing for wireless interaction with the Viewer. It provides the user with all necessary information

	about the device's diagnostics, the ability to start a new session, or connect the viewer to an available Wi-Fi network.
Operating System	Linux: Ubuntu
Power Source	12-Volts Tractors Battery
Energy Consumption	Clamp-metre with logger or Power Plug with logger (depending on the type of power connector in the tractor)

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
Image Data	Image Data offline which contains the images where tractor moved	mkv, jpg	JPG
GPS data	GPS Data offline, which contains the position and the velocity tractor moved	CSV with numerical data	CSV
Field type data	The inter/intra row distance of the vineyard field	Numerical data	YAML
Detection Data	The number of the detected fruits (yield estimation case)	Numerical data	CSV
	The canopy density profile of the vineyard (canopy profiling case)	Numerical data	CSV
	The number of the detected diseases (disease detection case)	Numerical data	CSV

4.2.3. Activities & Milestones

Activity No. 1	**Start month**	M03	**End month**	M36
Activity title	Co-Creation of Cloud and Mixed model-based ADS			
Activity goal	To deploy and operate the Viewer System for first analysis, data collection and software and hardware updates based on test trials.			
Activity description	This activity is focused on making the first analysis based on the field requirements, integrating the Viewer for deployment, data collection and updating the system based on the feedback from the 2 pilot trial cycles (Activity No.2). It will focus on the following sub-activities. **A1.1 Preparation and analysis [M03 – M05]:** Making an analysis for the different cellular or wireless connectivity options for both cloud and mixed/edge solutions. Get all proper field and crop type information (inter-row and intra-row field, phenological timeline of the vineyard) to enter this information in the software pipeline. Investigate software solutions for GPU cloud solutions and make a proper selection based on the price/specification for the cloud solution. Make a first investigation about measuring energy measurement approaches based on the type of power connectivity chosen (tractor battery or tractor power plug). **A1.2 Deployment and operation [M03 – M36]:** Assembly a viewer device dedicated to the project and integrate it in the tractor. The system will be calibrated to meet the field's needs. This device will serve both cloud and mixed solution, since the same hardware can perform both scenarios. Depending on the scenario tested (cloud and mixed approach), different software stacks and different internet communication strategies (cellular internet for mixed and wi-fi for cloud solution). **A1.2.1** Data collection for cloud and mixed solution for the first round of trials [M05 – M09]: The device will be used in this period to capture image data to train the first AI models for both three functionalities (disease detection, canopy profiling, yield estimation) for edge solution. This image data will be used manually annotated, training AI models and exporting the AI models into proper format to load them to the Viewer. We must notice that these models will be further enriched every time the Viewer operates in the edge solution since the Viewer can operate and in parallel capture image data that can be used to make the previous models even more			

	accurate. For the cloud solution the approach itself is a data collection strategy since the image data collection will be done and all this data will be transferred to train new models in every testing. **A1.2.2** 1st version of the Viewer (cloud and mixed) [M09 – M14]: The first version of the Viewer device for software and hardware for both approaches will be ready for deployment. Changes on the software stack that was already developed from Eden Library regarding the device and the dedicated tablet. Offline testing on Eden's premises before launching this version. **A1.2.3** 2nd version of Viewer (cloud and mixed) [M22 – M25]: Based on the outcomes of the first round of pilot trials (documented in the report from A2.6) we will check the drawbacks for both solutions in order to perform upgrades to the software or hardware that may be deemed necessary in the two solutions. **A1.2.4** Final version of Viewer (cloud and mixed) [M35 – M36]: A final version of the Viewer's software and hardware will be built based on the outcomes of the second testing period. **A1.3 Development of Open-Source hardware/software [M08 - M36]:** This activity will focus on making a substantial part of the gathered data and the preliminary versions of the AI models utilised in the project freely accessible for reuse. It will focus on the following sub-activities. **A1.3.1** Data collection during 1st Annual Cycle Testing [M15 – M21]: In the mixed approach the Viewer during testing will be capturing image data dataset for making the AI models even more accurate. For the cloud solution the image dataset will be captured anyway since it is part of the strategy. **A1.3.2** Data collection during 2nd Annual Cycle Testing [M26 – M34]: In the mixed approach the Viewer during testing will be capturing image data dataset for making the AI models even more accurate. For the cloud approach the image dataset will be captured anyway since it is part of the strategy. **A1.3.3** Release of a Pre-Final Version of the AI models [M34 – M36]: After the software and hardware updates of the second version of the Viewer, a pre-final version of the AI models and a part of the image dataset will be freely available for reuse as OS. **A1.4 Integration of the OpenAgri OS services to the ADS [M09-M36]:** This activity is focused on the integration of Pest Management, Digital Farm Calendar and interoperable Data Exchange and Access Control OpenAgri OS services with the Viewer Device. For the edge device approach the Viewer will be connected with the Pest and Disease Management service in order to alert the user and to choose more accurate models regarding the Disease Detection. In the same SIP approach the Viewer will send after each session in the Digital Farm Calendar OS service the farmer's activity, the parcel properties and the Viewer visual scouting functionality found (total diseases, total fruits counted, total canopy detected. Interactions with the OpenAgri OS services will be facilitated by the Interoperable Data Exchange and Access Control Service. It will focus on the following sub-activities: **A1.4.1** Testing services within the 1st Annual Cycle Testing [M15 – M24]: After the 1st annual cycle testing the drawbacks of the solution will be reported with the partners involved in order to perform software updates if needed. **A1.4.2** Software Updates [M22 – M25]: Software updates of the Viewer and in the OS services will be done based on the report on the previous testing. **A1.4.3** Testing services within the 2nd Annual Cycle Testing [M26 – M35]: Testing the same services based on the previous work done.
Participants involved	Leader: Eden Library; Participants: Kyr-Gianni/Tselepos wineries

Milestones

(Related to Activity 1 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Acquisition of proper data for the field trial	A1.1	Existence of all data field information: inter-row and intra-row field, phenological timeline of the vineyard	M04
2	Energy Measurement approach	A1.1	Approach defined and shared with WP1	M04
3	GPU cloud solution	A1.1	Approach defined and shared with WP1	M05

4	Analysis for the internet connectivity that will be used	A1.1	Approach defined based on the image data needs	M05
5	Assembly Viewer	A1.2	Existence of a viewer device dedicated for this project	M03
6	Integrate the system in the field	A1.2	Mount the Viewer system in tractor used	M05
7	Data collection on the first season	A1.2.1	Existence of the image data collection that will be used for the next season.	M09
8	1st version Viewer	A1.2.2	1st Version of the Viewer ready for deployment	M14
9	2nd version Viewer	A1.2.3	Software and hardware updates based on the reports from A2.4	M25
10	Final version Viewer	A1.2.4	Software and hardware updates based on the reports from A2.5	M36
11	Data collection on the first field trial	A1.3.1	Upload the total dataset in a server	M21
12	Data collection on the second field trial	A1.3.2	Release the 60% of the total dataset	M34
13	Release of Open pre-Final Version AI models	A1.3.3	Upload of the pre final version of the AI model	M36
14	Integration of OpenAgri OS services with Viewer	A1.4	Services integrated with the Viewer	M12
15	Testing services with Viewer	A1.4.1	Testing and Services during the 1st Annual Cycle Testing	M24
16	Software Updates	A1.4.2	Software Updates in the VIewer/OS services	M25
17	Testing Services with Viewer	A1.4.3	Testing and Services during the 2nd Annual Cycle Testing	M35

Activity No. 2	**Start month**	M05	**End month**	M35
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two growing seasons, aiming to evaluate the efficiency, performance and usability of the ADSs based on the established metrics.			
Activity description	This activity is focused on pilot testing for edge and cloud solutions It will focus on the following sub-activities. **A2.1 Selection of the Testing fields to test the 2 Viewer approaches developed in the SIP [M05 – M09]:** In this activity the proper selection of the vineyard pilot case will be done for both Viewer approach solutions. **A2.2 Design the testing phase for the Viewer [M09 – M14]:** We will organise a detailed plan with field visits based on the vineyard growing stage and the availability of the wineries. The Viewer will be placed in front of the tractor, and we will perform 4 vineyard rows (0.14 hectares). The cloud solution will firstly be used to capture the necessary data and will later upload into the GPU cloud server to train the AI models for the 3 functionalities and provide a with the 3 metrics in a map representation. After collection of the data for the mixed model-based solution, the mixed model-based approach will be tested after in the same field and same rows to perform the same functionalities using the pretrained models. The mixed solution will provide real time data in the EDEN's cloud, and the map representation will be created. A manual approach (number of diseases, number of grapes and canopy volume) will be done to compare the metrics provided from the cloud solution and mixed approach. As a manual approach for the disease detection and yield estimation we will count the number of diseases and the number of grapes, and those metrics will be used as ground truth for evaluating cloud and edge approaches. For the canopy profiling we will measure the 3 dimensions of the vineyard row (width, length and height) and these values will be used as a ground truth and these values will be evaluated based on the canopy profiling both approaches will output. Since spraying operation is based on				

	the velocity of the tractor for the 3 solutions, we will assume a constant velocity and we will calculate the spraying that should be applied in both solutions based on the foliage identification for mixed, cloud and manual measurements. **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** Conduct the piloting and testing activities to perform the dual comparison of the two ADS at the field. Following the project iterative approach, the activities will take place in two annual cycles. The work is split into the following sub-activities. **A2.3.1 1st Annual Cycle Testing [M15 – M21]:** The viewer will be placed in front of the tractor in order to perform in 4 vineyard rows (0.14 hectares) a field trial. ● For the cloud solution the viewer will capture the image data along with the GPS and will later upload in order to perform offline disease detection, yield estimation and canopy profiling in the GPU cloud node and create the maps as described in 1.1.3 section. ● For the mixed model-based solution, the viewer will perform a real-time yield estimation and canopy profiling functionality and disease detection online using the pretrained model we have acquired from M05-M09, and we will send the detection metadata in the Eden server in order to create the maps at the end of the trial. It must be noted that finding pests symptoms in a production winery due to seasonality is uncertain. In case of finding pest symptoms in Kyr-Gianni and Tselepos wineries, additional fields from Agricultural University of Athens will be used and artificial targets to emulate pest symptoms will be used. **Based on the collected data** the first SIP performance report will be completed based on the KPIs that were defined. **A2.3.2 2nd Annual Cycle Testing [M26 – M33]:** Based on the evaluation results, the second annual testing will take the same way as described in A2.3.1, to test the updated version of the ADS resulting from A1.2.3. **At the end of this phase,** the final report will include the results of the second phase of testing and an overall analysis of the performance of each mode (cloud and edge) of the solution.
Participants involved	Leader: Eden; Participants: Eden, Kyr-Gianni, Tselepos

Milestones
(Related to Activity 2 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Selection of the Testing fields	A2.1	Selection of the vineyard test fields	M09
2	Design the testing phase	A2.2	Detailed plan with field visits	M14
3	1st Annual Cycle Testing	A2.3.1	Perform 4 vineyard rows a field trial.	M21
4	1st SIP Performance report	A2.3.1	1st SIP Performance report	M24
5	2nd Annual Cycle Testing	A2.3.2	Perform 4 vineyard rows a field trial.	M33
6	2nd SIP Performance report	A2.3.2	Final SIP Performance report	M35

Activity No. 3	**Start month**	M06	**End month**	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is focused on presenting the results found for both edge/mixed and cloud solutions that will be based on the SIP outcomes. The following sub-activities will take place: **A3.1. Posts on Social media [M06 – M34]:** We will post social media material in M15-M21 and M27-M33 that contain field visits, testing the Viewer in vineyards. **A3.2. Organise an Open Day [M24 – M34]:** The SIP partners will organise an "Open day", where farmers, advisors and other agrifood actors from the wider region(s) will visit one of the fields of the pilot, to see how the mixed model-based and cloud-based ADSs are applied in practice, learn about their documented performance, interact and share experiences and good practices.			

	A3.3. Create one video testimonial [M03 – M34]: The SIP partners together with FSH will prepare a video testimonial that contains the user's input about the viewer's functionalities for yield estimation and canopy profiling and pest identification. **A3.4. Participate in Exhibition [M30 – M34]:** The viewer device will be exhibited in an agriculture related exhibition to demonstrate our results to stakeholders. **A3.5 Community Engagement Workshops for Co-Designing ADS [M06-M36]:** This sub-activity fosters community involvement in ADS development. P2PLab will lead two workshops to train SIP partners on participatory engagement practices and create a working group that includes farmers, farm advisors, and tech startups. The aim is to co-develop community outreach and integration protocols, leading to major co-design kickstart events and successive workshops. These activities aim to develop at least five new community-driven, open-source ADSs that are socially inclusive, responsible, and sustainable.
Participants involved	Leader: Eden; Participants: Eden, Kyr-Gianni, Tselepos

Milestones
(Related to Activity 3 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Social media posts	A3.1	10 posts until deadline	M34
2	Organise Open Day	A3.2	Pilot showcase of the project outcomes	M34
3	Video testimonial	A3.3	A video testimonial posts on Eden and Open Agri social media	M34
4	Participate in Agriculture related Exhibition	A3.4	Participate in Agriculture related Exhibition	M34
5	Completion of Community Engagement Workshops	A3.5	Workshop attendance logs, workshop training materials, reports on workshop outcomes, documentation of co-developed ADS protocols and designs	M36

4.2.4. Dissemination & Demonstration activities

Dissemination & Demonstration activities

Activity	Chanel Type	Frequency	Targeted audience group	Dissemination materials
Create social media posts and spread them through the partners' accounts and the Open Agri accounts.	Social Media	Eden will provide in total 8 social media posts during the testing trials from March to September.	All	Pictures from the field, stories, other material
One Open Day will be launched in Kyr-Gianni or Tselepos wineries to demonstrate the SIP results on the field.	Demonstration Events	Once in the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	A video showcasing the 2 ADS describing their benefits and presenting the results.

4.2.5. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	SIP1 will use 2 ADS (a cloud and a Mixed based). We will utilise 1 Viewer with different software
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	SIP1 will release a dataset comprising 60% of the image data collection and a pre final version of the AI models used.
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	1	SIP1 will co-create the 2 ADSs and execute the pilot activities at Tselepos and Kyr-Gianni wineries engaging 1 vineyard manager
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	Eden will host 1 open day at the facilities of Tselepos wineries demonstrating the 2 ADSs
Open Day Participants	Number of people participating in the Open Days	0	20	For the open day at Tselepos wineries there will be engaged 20 farmers and advisors will be invited to check the 2 ADSs developed.
Social Media Posts	Number of Social Media post	0	8	Eden will provide in total 8 social media posts during the testing trials from March to September.
Video testimonials	Number of Video testimonials created.	0	1	Eden will provide 1 video testimonial with the help of WP4 partners for the edge and mixed approach

4.2.6. Evaluation & Comparison metrics

Effectiveness and Performance in Agriculture Scenarios

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 5 - Evaluation metrics for effectiveness and performance in agriculture scenarios for SIP1

No	Metric	Notes
1	**Speed/time needed to complete detection and spraying**	The performance of the system will be measured comparing the two approaches (mixed and cloud solution) by measuring the services of Viewer's services. The **total time** that is needed for 1 foliage detection, 1 disease detection and 1 fruit detection will be measured in terms of seconds for the mixed and cloud solution. Apart from the aforementioned services the total time needed for applying 1 spraying recommendation value will be measured. For estimating a spraying recommendation value two variables will be needed: the canopy foliage detection and also the velocity of the tractor that will be considered as constant for this test.

2	**Accuracy of disease detection mode**	Accuracy of the disease detections refers to the number of diseases that can be achieved from the AI models using the cloud and the mixed approaches vs the manual measurements.
3	**Accuracy of yield estimation mode**	Accuracy of the fruit detections refers to the accuracy of the number of fruits counted that can be achieved from the AI models using the cloud and the mixed approaches vs the manual measurements.
4	**Accuracy of the spraying recommendation values**	Accuracy of the spraying recommendation values will be based on the canopy profiling that the AI model generated (mm3/s) based on a constant value. We will perform manual measurement of the canopy in order to evaluate the accuracy of the cloud and mixed solution
5	**Minimization of the overall environmental footprint**	For the canopy profiling we will measure the 3 dimensions of the vineyard row (width, length and height) and these values will be used as a ground truth and these values will be evaluated based on the canopy profiling both approaches will output. Since spraying operation is based on the velocity of the tractor for the 3 solutions, we will assume a constant velocity and we will calculate the spraying that should be applied in both solutions based on the foliage identification for mixed, cloud and manual measurements.

Computing Resource Utilization and Energy Efficiency

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 6 Evaluation metrics for computing resource utilization and energy efficiency for SIP1

No	Metric	Notes
1	**Networking resources** utilisation for data transmission. A comparison when transmitting raw images (cloud case) vs calculated outcomes (edge processing).	Different networking protocols for edge vs cloud communications will be utilised. E.g. WiFi, 3/4G.
2	**Computing resources** utilised against different levels of AI model accuracy for all functionalities (disease,yield,canopy profiling)	Performance depends on the allocated computation/networking resources and generated workload (images for processing).Different AI configurations.
3	**Energy consumed for data transmission and processing**	Aggregation of consumed energy based on the different deployment scenarios.
4	**Total energy consumed** for completing the farming operation maintaining a “basic?” accuracy threshold for disease recognition and pest detection.	This will include energy calculated in metric 3 but also the energy consumed from the operation of the equipment (e.g. tractor).

Comparison Metrics Overview

Table 7 – SIP1 Comparison Metrics

SIP1 Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Speed/time needed to complete disease detection	The total time that is needed for 1 detection in the mixed and cloud solution for a disease detection.	Seconds to have a disease detection
Speed/time to complete a yield estimation detection	The total time that is needed for 1 detection in the mixed and cloud solution for a yield estimation detection.	Seconds needed in order to have a yield estimation detection

Speed/time to complete a canopy profiling detection	The total time that is needed for 1 detection in the mixed and cloud solution for a canopy profiling detection.	Seconds to have a detection of canopy
Speed/time to complete a spraying recommendation	The total time that is needed for 1 spraying recommendation based on canopy profiling and a constant tractor value	Seconds needed for a spraying recommendation value
Accuracy of disease detection mode	Accuracy of the disease detections refers to the number of diseases that can be achieved from the AI models using the cloud and the mixed approaches vs the manual measurements.	Number of detected diseases vs manual measurements.
Accuracy of yield estimation mode	Accuracy of the fruit detections refers to the accuracy of the number of fruits counted that can be achieved from the AI models using the cloud and the mixed approaches vs the manual measurements.	Number of fruits detected vs manual measurement.
Accuracy of the canopy profiling values.	Accuracy of the canopy profiling that the AI model generated (mm3) vs manual measurement of the canopy (width, length and height)	The number of the total canopy in mm3 that is calculated for both approaches vs manual measurement.
Minimization of the overall environmental footprint	In order to evaluate the overall environmental footprint, the spraying recommendation functionality will be used. The aggregation of all offline-generated spraying commands will be compared to manual spraying, which is done without any variable spraying.	mm3/s needed for offline variable spraying vs settings standard manual spraying command in mm3/s.
Computing & network resources utilisation and energy efficiency		
Networking resources utilisation for data transmission.	A comparison when transmitting raw images (cloud case) vs calculated outcomes (edge processing). For the Mixed solution a 3G Connectivity will be used and in the Cloud solution a Wi-Fi connection.	Total MB consumption
Computing resources utilisation in both solutions.	The computing resources utilisation for both solutions can be seen based on the maximum performance in terms of Frames Per Second can be achieved for both mixed and cloud solutions.	Average Frame per second (FPS)
Energy consumed for data transmission and processing	Aggregation of consumed energy based on the different deployment scenarios.	Watt consumption
Total energy consumed for completing the farming operation	This will include energy calculated in metric 3 but also the fuel consumption of the tractor. In order to calculate the consumption we will manually record the amount of fuel added to the tractor and the hours of operation.	Watt consumption and fuel consumption (Lt/km)
Use of Standards / Interoperability and Switchability		

Evaluation of Data Standards and File Formats	Analysis of data modelling approaches, standardisation mechanisms, barriers, and benefits.	List and short report analysing data modelling and standardisation mechanisms.
Evaluation of Networking/Communication Standards	Analysis of technical specifications of networking/communication standards, including barriers and benefits.	List and short report analysing telecom and IoT communication protocols.
Switchability of Software Modules	Evaluation of the potential to reuse software services in different contexts using containerization technologies.	Report analysing reusability of software modules with containerization technologies (e.g., Docker).
Switchability of Farm Data Collections	Evaluation of the feasibility of retrieving and reusing farm data collections with solutions from different providers.	Report analysing reusability of farm data collections.
Switchability of Hardware Modules	Evaluation of the potential to reuse hardware services in different contexts, focusing on plug and play mechanisms and hardware protocols.	Report analysing reusability of hardware modules.

4.2.7. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**
Assembly of the device can be delayed due to supplier latencies	A1.2	Start building the devices from M03
Internet Connectivity issues in the field	A1.2	Cellular internet connectivity can be unstable in the field, so we will find more robust internet connections like Wi-Fi.
The pilot doesn't lead to the expected results due to extreme environmental conditions or other unforeseen situations	A1.4	The SIP will run for two growing seasons to address such problems.
Lack of disease symptoms in production wineries	A2.3 and A2.5	In case of finding pest symptoms in Kyr-Gianni and Tselepos wineries, additional fields from Agricultural University of Athens that are located in Spata, Greece, will be used and artificial targets to emulate pest symptoms will be used.

4.3. SIP2 Execution Plan

SIP name	SIP coordinator(s) Contact Info
Use of UHF electronic identification to remotely monitor cattle and detect changes in their state of health by monitoring frequentation of watering area.	Sébastien Duroy sebastien.duroy@idele.fr

SIP GENERAL INFORMATION	
SIP sector(s)	Livestock
Agri-food sector	Production
Geographical coverage (Country/ Region)	France / Britany
SIP Partners	IDELE, CIRBEEF
Farmers & Advisors involved	CIRBEEF farm
SIP Challenge (Need/Problem)	In extensive beef production, farmers make daily visits to the various grazing areas to ensure that the animals are present and in good health. However, pastures are sometimes a long way from the farm, and the daily round of grazing can be a time-consuming task. Having remote information on the presence and normal behaviour of animals is a real service for the farmer. Without taking the place of on-site visits by the farmer, regular remote information would enable the farmer to either postpone the grazing round slightly to concentrate on other tasks, or to intervene more rapidly in the event of an alert of abnormal/unexpected behaviour, a possible sign of a change in health status.
ADS Overview	The SIP2 ADS is an animal monitoring solution based on UHF RFID. The principle for remote monitoring of animals in extensive grazing areas will be based on monitoring drinking behaviour, or more precisely regular attendance at the watering trough area. Tracking the animal's location could be done using expensive sensors (such as GPS), but we have opted for a low-cost technology, UHF electronic identification (UHF RFID). In fact, UHF RFID is based on the use of passive ear tags with no embedded energy. The principle of ADS is to detect the presence of the ear tag (i.e. the animal) in the area of the water trough covered permanently 24/24 by the electromagnetic field of the UHF RFID reader. Detection of the ear tags will make it possible to determine individual visiting periods for each animal and thus to create expected patterns of frequentation, or conversely to generate non-attendance alerts if one or more animals are not detected for a certain period of time. The RFID reader system will be connected to a 4G/5G router so that data can be communicated remotely. Depending on the solution (cloud or edge), the farmer can use a back-office website or a smartphone application. We already have a first back-office version. The app will have to be fully developed.
Other Data uses	The RFID UHF records provide evidence on the duration and area (pasture) that livestock were grazing and can provide input to the farm calendar for pasture management and other reporting needs.

4.3.1. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**
IDELE	R&D test centre for livestock	SIP leader	Brittany / France	Sébastien Duroy sebastien.duroy@idele.fr
CIRBEFF	Innovation centre, experimental farm, end users	Affiliated member	Brittany / France	Frédéric Guy Frederic.guy@idele.fr

4.3.2. Co-created ADS & Data involved in the SIP

ADS Description

The principle of ADS is to detect the presence of the ear tag (i.e. the animal) in the area of the water trough covered by the electromagnetic field of the UHF RFID reader.
Detection of the UHF ear tags will make it possible to determine individual visiting periods for each animal and thus to create expected patterns of frequentation, or conversely to generate non-attendance alerts if one or more animals are not detected for a certain period of time. Meteorological data will be taken into account to assess the impact on water trough attendance and may be integrated into the algorithm for creating alerts.
The RFID reader system will be connected to a 4G/5G router so that data can be communicated remotely. Depending on the solution (cloud or edge), the farmer can use a back-office website or a smartphone application.
We plan to test a cloud vs. edge mode (without network connection):

- The cloud mode consists of uploading all raw data to the cloud, creating visits and generating individual non-attendance alerts as soon as the time limit (chosen by the breeder) has been exceeded. Weather data will be linked in this mode to refine the creation of alerts.
- The edge mode will be based on a solution with no network connection, to provide a digital solution even if the network connection is too weak. The principle is based on farmers' current work rhythm, i.e. on-site checks (at the pastures) every 48 hours. In edge mode, the farmer will need to pair his smartphone up with the device via Bluetooth and download from the device a report on watering trough attendance over the last 48 hours.

Cloud based ADS Architecture

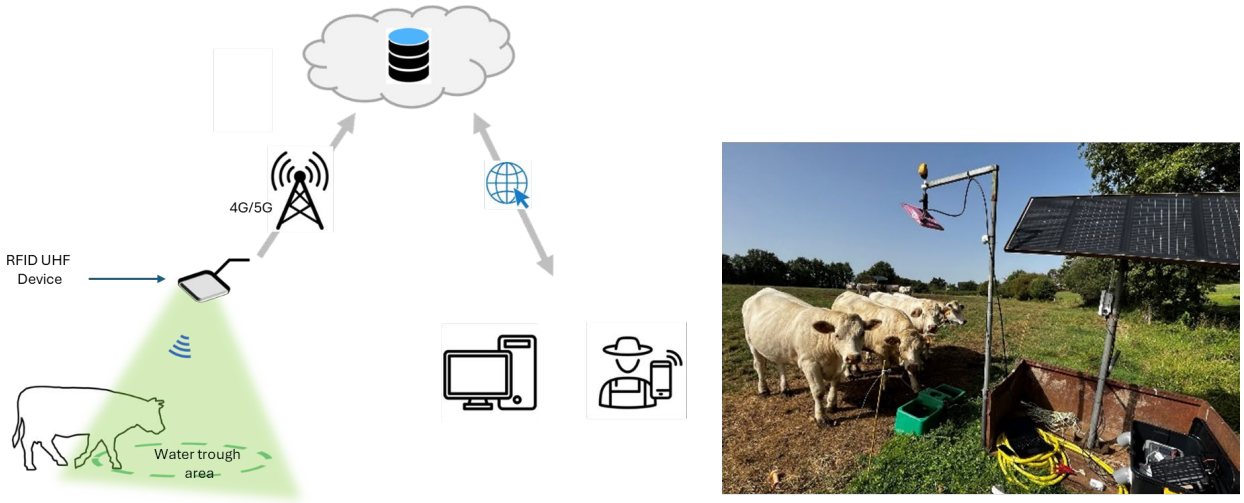


Figure 3 Architecture of UHF RFID ADS in cloud system

The UHF RFID device is a communicating suitcase. It consists of a mini-PC (beagleboard), a fixed UHF RFID reader and a Bluetooth module. The mini-PC controls the device and communication with the user (for settings) is via a smartphone application that pairs with the device via Bluetooth. The device is connected to:
- a router to send data via 5/4G/5G network to a remote database,
- a power pack with a solar panel, and motion sensors for optimised power management.

The user has access to a back-office portal to consult the data, define the criteria for aggregating the UHF RFID data to generate visits to the water trough and set up alerts. Alerts are sent by email from the back office. The farmer can choose the period of non-attendance after which he wants to be alerted.
Weather data will be taken into account to refine the algorithm for generating real-time alerts

Maturity of the ADS	Current TRL	TRL Goal [M36]
	6-7	8

Edge based ADS Architecture

In the edge version, the device is the same, but all calculations will be made locally by the device. There will be no remote database. Users will only be able to retrieve traffic reports when they get close to the device. For this purpose, a special smartphone app will be developed. If possible, Weather data will be integrated to the report functionality.

Compared to the cloud version, the service is not as responsive because the farmer will only get a frequentation report every 48h by Bluetooth pairing (when he goes to the pastures). However, this solution has the advantage of not being dependent on a network connection. In this sense, it can provide solutions for farmers in areas with no telephone or internet connection (mountains, for example).

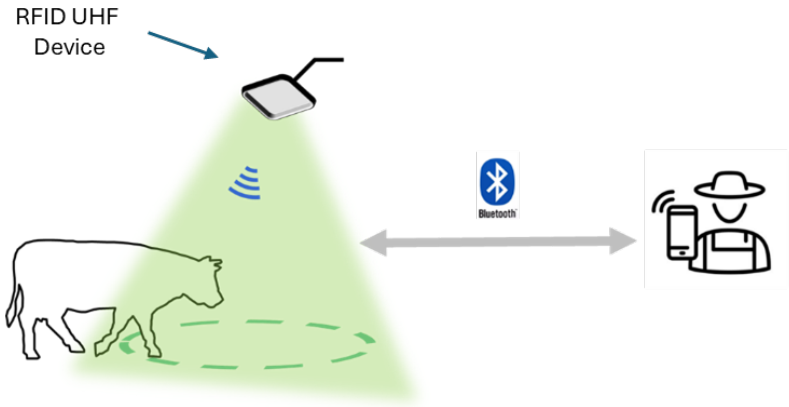


Figure 4 Architecture of UHF RFID in edge system

Maturity of the ADS	Current TRL	TRL Goal [M36]
	5	8

OpenAgri OS services used

For the Cloud version, weather data will be used to refine the accuracy of drinking through attendance patterns and considered in the algorithm for generating alerts. The OpenAgri OS weather service will be used for assisting the alerting process through the provision of animal welfare related weather indexes (e.g. Heat index, Hear Load Index). In addition, this SIP will reuse the OpenAgri OS Farm calendar and the OpenAgri OS Reporting service for recording/maintaining information about the herd status in a semantically interoperable way.

OS Software &/or Hardware developed

Pattern recognition algorithm and collected training datasets will be public and ready-to-use:
Cloud mode / back-office: specific functions need to be developed to take account of the weather service in the algorithm for calculating visits to the trough.
Edge mode: the device's specific operating system (installed on the beagleboard) will be adapted to calculate visits to the trough locally and produce a visit report that can be downloaded via Bluetooth to the farmer's smartphone.

Current Design of the ADS

Devices/ Equipment	Beagleboard, Bluetooth module, motion sensors, smartrac UHF ear tags, impinj 420 UHF reader, 5G router
Operating System	The OS (installed on the beagleboard) has the following functions: It controls the reader, monitors the correct operation of the device,

	sends data to the DB and uses dedicated commands to communicate with a setting mobile app. ● UHF ear tags to the reader: protocols communication are defined by the ISO 18000 pool of standards and the recently published ISO 6881 standard. ● Device to database (cloud mode): 4G/5G connection ● Device to farmer's phone: standard Bluetooth
Power Source	Power Pack and solar panel (models to be defined)
Energy Consumption	Current and voltage data logger use to measuring the consumption of complete RFID UHF device (RFID reader, 4G router, mini-pc) Energy consumption data supplied by the cloud solution provider

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
RFID detection	tag ID	Numerical data	csv
	read count per second	Numerical data	
	date and time of reading	Date, time	
	RSSI	Numerical data	
Visit at the water trough	tag ID	Numerical data	csv
	date and time of start of visit	Date, time	
	date and time of end of visit	Date, time	
	Duration (s)	Numerical	
	read count	Numerical	
	RSSI	Numerical	
Cattle health register	tag ID	numerical	
	Illness name	Textual	
	Medication	Textual	

4.3.3. Activities & Milestones

Activity No. 1	**Start month**	M03	**End month**	M36
Activity title	Co-Creation of Cloud and Edge based ADS			
Activity goal	This activity focuses on the joint development, initial implementation and validation of cloud and edge solutions for monitoring cattle watering area use. It will focus on the following sub-activities:			
Activity description	This activity is focused on making the first analysis based on the field requirements, data collection and updating the system based on the feedback from the 2 pilot trial cycles (Activity No.2). It will focus on the following sub-activities. **A1.1 Preparation and analysis [M03 – M09]:** The challenge is to implement a system that is robust enough to withstand the various movements between pastures. During the grazing period, the herd will move from one paddock to another. It will be necessary to be able to use a device that can be moved easily. Thus, it is necessary to refine user requirements for cloud and edge modes operation in consultation with the experimental farm's breeders and technicians and also draw up arrangements for protecting the device to prevent any damage by animals during grazing periods. **A1.2 Deployment and operation [M07 – M36]:** Assembly a first RFID UHF device for the phase of reading data collection. Test and validate the operational function of the battery and solar panel. **A1.2.1 Data collection for cloud and mixed solution for the first round of trials [M10 – M11]:** The reading data collected will be used to define the procedures for creating visits to the drinking trough. Using a real dataset collected from reading the animals in the herd, simulations will be carried out to determine the appropriate parameters (P1 = time between visits and P2 = minimum duration).			

	A1.2.2 1st version of ADS (cloud and edge) [M10 – M15]: At the end of M16, for the launch of the first annual pilot tests, the first version of the for both approaches will be ready for deployment. development of the OS and new application only for the edge version and testing of the device in the office. **A1.2.3** 2nd version of ADS (cloud and edge) [M22 – M27] Based on the results of the first series of pilot tests (documented in report A2.4), we will make the necessary improvements to the various parts of the solution: hardware, device OS, back-office and user app. **A1.2.4** Final version of ADS (cloud and edge) [M33 – M36]: A final version of the solution will be corrected based on the results of the second trial period. **A1.3 Development of Open-Source software [M9-M33]** This activity is focused on developing open-source software solutions It will focus on the following sub-activities: A1.3.1 Data collection during 1st and 2nd Annual Cycle Testing [M09 – M26]: For calculating water trough visits, the data processing (rules engine) along with datasets of an RFID UHF readings will be offered as open-source software. A1.3.2 Release of a Pre-Final Version of water trough frequentation solution [M28 – M33]: Documentation, software and hardware designs, best practices and lessons learned of water area monitoring pilots will be available to the open-source community. **A1.4 Integration of the OpenAgri OS services to the ADS [M09 – M36]:** This activity aims to integrate the OpenAgri OS services that are available and relevant to the operation of the ADS. It will focus on the following sub-activities: **A1.4.1** Testing services within the 1st Annual Cycle Testing [M15 – M24]: Review the functionalities offered by the OpenAgri OS services ("Weather Data Service" in particular). Design and provide technical specifications for integrating the OpenAgri OS service with the ADS for monitoring the use of the watering area by cattle. **A1.4.2** Implement Integration [M11 – M14] : Optimise ADS performance taking into account weather data. **A1.4.3** Testing services within the 2nd Annual Cycle Testing [M18 – M33] : testing and validation of the final version of OS OpenAgri services applied to the real conditions of the annual test cycles.
Participants involved	Leader: IDELE, Participants: CIRBEEF

Milestones

(Related to Activity 1 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Expression of need	A1.1	OS and app technical specifications	M09
2	Design and assembly of the device	A1.2	1st functional device version ready to be used for collecting data on animals (see A.1.3)	M09
3	Defining visit parameters	A1.2.1	data sets available, values for P1 et P2	M11
4	1st version of ADS	A1.2.2	1st Version of the solution ready for deployment	M15
5	2nd version of ADS	A1.2.3	Software and hardware updates based on the reports from A2.4	M27
6	Final version of ADS	A1.2.4	Software and hardware updates based on the reports from A2.5	M36
7	Data collection during 1st and 2nd Annual Cycle Testing	A1.3.1	Rules engine along with datasets of an RFID UHF readings	M26
8	Release of an OS program for calculating drinking trough visits	A1.3.2	Upload of the program final version	M33

9	Integration of OpenAgri OS services to the ADS	A1.4	Services integrated with the ADS	M36
10	Testing services with the ADS	A1.4.1	Testing and Services during the 1st Annual Cycle Testing	M24
11	Implement integration	A1.4.2	Optimisation of ADS by factoring in weather data	M14
12	Testing Services with ADS	A1.4.3	Testing and Services during the 2nd Annual Cycle Testing	M33

Activity No. 2	**Start month**	M10	**End month**	M35
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two growing seasons, aiming to evaluate the efficiency, performance and usability of the ADSs based on the established metrics.			
Activity description	This activity is focused on pilot testing for edge and cloud solutions It will focus on the following sub-activities. **A2.1 Design the testing phase [M10 – M15]:** A detailed plan for the pilot trial will be drawn up based on the following elements: - The trial will be carried out on a rotating basis on several pastures located approximately 12 km from the farm *(nota: the location of the trial is already known, so a specific task on this matter is not necessary)* - Each of the pastures has a fixed watering point with a trough, - The surface area of the pastures varies. The smallest is 3 ha and the largest is 22 ha, with some relief. This is why, if the animals are not present near the watering place, it can take time to approach and see them in large pastures, - The device will be moved at the same time as the animals, except for small pastures where the animals do not stay long enough, - Farmers visit pastures every 48 hours, - For both years, the pilot will be conducted over the grazing period from March to the end of August. If there is a need for additional measurements after August, the system could be moved to pastures close to the farm. **A2.2 Comprehensive ADS Testing and Reporting [M15-M34]:** Conduct the piloting and testing activities to perform the dual comparison of the two ADS at the field. Following the project iterative approach, the activities will take place in two annual cycles. The work is split into the following sub-activities. **A2.2.1 1st Annual Cycle Testing [M16 – M21]:** For the cloud solution, use and settings will be made on the office computer, as everything will be managed at back-office level (apart from receiving alerts). There are no plans at this stage to make the back-office website compatible with a smartphone (Ios or Android). Alerts will be sent by email, so they will be accessible on smartphones. For the Edge solution, the farmer will read reports every 48 hours as he moves around the plots. To do this, they need to connect via Bluetooth to a dedicated Android application. He will then be able to retrieve information on watering frequency over the last 48 hours. The report will be drawn up using visual indicators (green/orange/red) according to the rate of non-attendance observed compared with the expected attendance. The information will be detailed for the herd and for each animal. The farmer will check the automatic inventory made by the device and the health status of the animal. **Based on the collected data** the first SIP performance report will be completed based on the KPIs that were defined. It will cover following topics: - hardware robustness and operation, - performance assessment of automatic inventories, - quality and relevance of the alert system, - suggested improvements for the 2nd test phase... **A2.2.2 2nd Annual Cycle Testing [M28 – M33]:** Based on the evaluation results, the second annual testing will take the same way as described in A2.2.1, to test the updated version of the ADS resulting from A1.4.			

	At the end of this phase, the final report will include the results of the second phase of testing and an overall analysis of the performance of each mode (cloud and edge) of the solution.
Participants involved	Leader: IDELE; Participants: CIRBEEF

Milestones
(Related to Activity 2 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Design the testing phase	A2.1	Detailed plan	M15
2	1st Annual Cycle Testing	A2.2.1	water trough visit data records (cloud) water trough frequentation reports (edge)	M21
3	1st SIP Performance report	A2.2.1	1st SIP Performance report	M24
4	2nd Annual Cycle Testing	A2.2.2	water trough visit data records (cloud) water trough frequentation reports (edge)	M33
5	Final SIP Performance report	A2.2.2	Final SIP Performance report	M35

Activity No. 3	**Start month**	M6	**End month**	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is focused on presenting the results found for both edge and cloud solutions that will be based on the SIP outcomes. The following sub-activities will take place: **A3.1. Posts on social media [M06 – M34]:** We will post social media material in M16-M21 and M28-M33 that will include posts on setting up the system on grazing sites, explaining how it works (cloud/edge), etc. **A3.2. Organise an Open Day [M24 – M34]:** The SIP partners will be organising an "open day", during which a demonstration/presentation will be given to farmers, advisers and other players in the livestock sector from the region(s) concerned, to discover and understand the benefits of the cloud and edge versions of ADS, to learn more about remote animals monitoring, and to interact and share their experiences. **A3.3. Create one video testimonial [M03 – M34]:** The SIP partners together with FSH will prepare a video testimonial that contains the users' input about the ADS functionalities for remote animals monitoring and warning system of changes of health status. **A3.4 Community Engagement Workshops for Co-Designing ADS [M06-M36]:** This sub-activity fosters community involvement in ADS development. P2PLab will lead two workshops to train SIP partners on participatory engagement practices and create a working group that includes farmers, farm advisors, and tech startups. The aim is to co-develop community outreach and integration protocols, leading to major co-design kickstart events and successive workshops. These activities aim to develop at least five new community-driven, open-source ADSs that are socially inclusive, responsible, and sustainable.			
Participants involved	Leader: IDELE and CIRBEEF; Participants:			

Milestones
(Related to Activity 3 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Social media posts	A3.1	10 posts until deadline	M34
2	Organise Open Day	A3.2	Pilot showcase of the project outcomes	M34
3	Video testimonial	A3.3	A video testimonial posts on www.idele.fr and Open Agri social media	M34

4	Completion of Community Engagement Workshops	A3.4	Workshop attendance logs, workshop training materials, reports on workshop outcomes, documentation of co-developed ADS protocols and designs	M36

4.3.4. Dissemination & Demonstration activities

Dissemination & Demonstration activities				
Activity	**Chanel Type**	**Frequency**	**Targeted audience group**	**Dissemination materials**
Create social media posts and spread them through the partners' accounts	Social Media	IDELE will provide in total 10 social media posts during the testing trials from March to September.	All	Pictures from the field, stories, other material
One Open Day will be launched in CIRBEEF Farm to demonstrate the SIP results on the field.	Demonstration Events	Once in the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	A video showcasing the 2 ADS describing their benefits and presenting the results.

4.3.5. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	SIP2 will use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software developed and used in the SIP	Number of OS Software developed and used in the SIP	0	1	SIP2 will develop ≥1 OS Software
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	2	SIP2 will engage real actors in co-creation and piloting
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	SIP2 will host 1 Open Day
Open Day Participants	Number of people participating in the Open Days	0	30	For the Open Day at CIRBEEF farm there will be engaged 20 farmers and advisors will be invited to check the 2 ADSs developed.
Social Media Posts	Number of Social Media post	0	10	SIP2 will do one post every month during the testing trials.
Video testimonials	Number of Video testimonials created.	0	1	SIP2 will create 1 video testimonial with the help of WP4 partners.

4.3.6. Evaluation & Comparison metrics

Effectiveness and Performance in Agriculture Scenarios

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 8 - Evaluation metrics for effectiveness and performance in agriculture scenarios for SIP2

No	Metric	Notes
1	**Accuracy of ML models for measuring visits to water trough**	The SIP2 ADS's concept is based on recording animal visits to the water trough area. A visit is a period of time with a beginning (arrival time) and an end (departure/end time). Correctly defining visits is the first step, the keystone of the system. RFID readings are time-stamped data supplied per second by the device. So, we'll need to make choices about how to group data by second to create visits. For example, a visit to the drinking trough will have to last a certain amount of time to be considered a visit. Similarly, we'll also need to determine the maximum time between 2 readings, beyond which 2 different visits must be considered. Two parameters are used to aggregate the raw data per second into visits: - Param1 (P1): delay between 2 visits (s) - Param2 (P2): minimum duration of the visit (s) The choice and validation of parameters will be based on visual and/or video observations. So, this metric is to check the accuracy of the algorithm used to create the visits.
2	**Overall performance in herd monitoring**	The aim of the second metric is to check the performance of automatic inventory function: This will involve checking consistency between information on presence at the water trough and on-site checks every 48 hours. To check the performance of the inventory function, we'll need to continuously compare the number of animals detected by the device with the number of animals actually present in the watering area. To do this, we'll need to compare the data supplied by the device with visual observations (and perhaps GPS data if we can equip a few sentinel animals).
3	**Overall performance in detection of changes in drinking behaviour** (which may constitute an alteration in health status)	This metric changed from sickness detection to detecting changes in drinking behaviour, because the system aims to identify behavioural drift or any abnormal/unexpected behaviour, not just specific illnesses. Changes in water trough attendance can signal the start of a disease. Overall, the aim of this metric is to check the accuracy of the alert system by measuring its sensitivity and specificity. To this end, thresholds for water trough attendance frequentation and criteria for triggering alerts will be defined. If the animal does not use the drinking trough for a certain period (which can be set by levels), this will be considered as unexpected/abnormal behaviour and this will trigger an alert. 3 non-attendance delays could be defined in consultation with breeders and according to their expectations. For example, level 1 (12h), level 2 (18h), level 3 (24h). The number of expected visits will certainly have to be adjusted according to weather conditions. Weather conditions could have an impact (upwards or downwards) on the frequentation at the water trough. Therefore, Weather data will be taken into account to refine the algorithm for generating real-time alerts (cloud version), and if possible, to be integrated to the report functionality of the edge version. To assess the device's performance in detecting these changes, sensitivity and specificity levels will be assessed by comparing alerts with the observations made by the breeders on the animal's state of health.
4	**Cost efficiency/ effectiveness**	Depending on the effectiveness of the "cloud" and "edge" solutions, farmers may be able to extend the time between checking at the pastures. For instance, if the operation and quality of the data transmitted by the ADS are good enough, the farmer will be able to visit remote pastures every 3 days rather than every 2 days. At the end of the grazing season, this will have saved related costs such as fuel. The number of pasture visits and the corresponding fuel consumption for each visit are known and easily

		measurable. These data will be used to calculate the total cost for both the cloud and edge ADS. The total cost will include both the fuel consumption and the costs of each system. By comparing these total costs, the more cost-efficient solution will be identified.
5	**Time saved from visits**	The total time saved using cloud and edge ADS can be calculated by multiplying the number of visits by the time consumed per visit. For instance, cloud ADS results in 15 hours saved (15 visits x 1 hour per visit) and edge ADS results in 17 hours saved (17 visits x 1 hour per visit). Additionally, the number of visits the farmer makes without using an ADS for reference will be estimated. This comparison helps in understanding the efficiency gains from using ADS systems.

Computing Resource Utilization and Energy Efficiency

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 9 Evaluation metrics for computing resource utilization and energy efficiency for SIP2

No	Metric	Notes
1	**Networking resources** utilisation for data transmission. Data will refer to animal presence approaching the base station.	In cloud solution, all ear-tag RFID recording, and environmental parameters will be transmitted to the cloud. In edge solution, only summaries/alerts/notifications that will be the outcome of processing in the local device will be transmitted.
2	**Computing resources** utilised when processing of animal activities is performed in the cloud vs edge devices.	This will be evaluated against different levels of accuracy for the ML models (pattern identification and unexpected behaviour) deployed on edge vs cloud.
3	**Total energy consumed for data processing and transmission**	Aggregation of consumed energy based on the different deployment scenarios.
4	**Total energy consumed for completing the farming operation.**	This will include energy calculated in metric 3 in combination with the energy required for performing the task, e.g. number of visits in the remote area for looking after the cows.

Comparison Metrics Overview

Table 10 – SIP2 Comparison Metrics

SIP2 Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Accuracy of ML models for measuring visits to water trough	Aggregates RFID data to get realistic periods of attendance (visits) at the water trough	accurate and representative data of the water trough frequentation behaviour per animal per day (number of visits, duration)
Overall performance in herd monitoring	Monitoring the regular trough frequentation by every animal of the herd through UHF RFID detections (nb animals detected vs expected, nb of visits per animal detected vs expected)	Regular information on the general state of the herd
Overall performance in detection of changes in drinking behaviour	The quantity and quality of alerts issued by the system will be assessed and validated by comparing them with observations	Relevant alerts sent to the farmer in the event of unexpected animal behaviour

	made by farmers on the animal's state of health.	
Cost efficiency/effectiveness	The number of pasture visits and the fuel consumption/costs will be recorded each time. Fuel savings will thus be compared with the current situation (without ADS), which is based on a field check every 48 hours.	Fuel savings and identification of the more cost-efficiency solution
Time saved from visits	The total time saved using cloud and edge ADS can be calculated by multiplying the number of visits by the time consumed per visit.	Time saving
Computing & network resources utilization and energy efficiency		
Networking Resources Utilization for data transmission	Amount of raw RFID readings data transmitted in the case of the cloud version. A 4G/5G connection will be used. No data transmission in the edge solution.	Total MB consumption
Computing Resources Utilisation	Evaluates the computing load, data processing and storage space required for data backup in the cloud scenario compared with the edge scenario.	Savings in computational resources used.
Total Energy Consumed for Data Processing and Transmission	Calculates the energy used in monitoring, data transmission.	Watt consumption
Total Energy Consumed for Completing the Farming Operation	Accounts for the energy used to travel to remote grazing areas	Fuel consumption
Use of Standards / Interoperability and Switchability		
Evaluation of Data Standards and File Formats	Analysis of data modelling approaches, standardisation mechanisms, barriers, and benefits.	List and short report analysing data modelling and standardisation mechanisms.
Evaluation of Networking/Communication Standards	Analysis of technical specifications of networking/communication standards, including barriers and benefits.	List and short report analysing telecom and IoT communication protocols.
Switchability of Software Modules	Evaluation of the potential to reuse software services in different contexts using containerization technologies.	Report analysing reusability of software modules with containerization technologies (e.g., Docker).
Switchability of Farm Data Collections	Evaluation of the feasibility of retrieving and reusing farm data collections with solutions from different providers.	Report analysing reusability of farm data collections.
Switchability of Hardware Modules	Evaluation of the potential to reuse hardware services in different contexts, focusing on plug and play mechanisms and hardware protocols.	Report analysing reusability of hardware modules.

4.3.7. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**
Assembly of the device can be delayed due to supplier latencies	A1.2	Use an earlier version of the device
Inability to collect data on remote pastures due to delay in developing the solar energy system	A1.3	Work temporarily close to the farm using the electricity network
Inability to collect data on remote pastures due to animals moved to other locations for herd management reasons	A1.3	Work temporarily on pastures close to the farm with other animals from the herd
Lack of abnormal drinking behaviour to assess the relevance of the alert system due to the limited size of the experimental herd	A2.2, A2.4	Simulation work on deliberately shortened non-attendance times to artificially increase the number of alerts.
Unstable mobile internet network in targeted pastures for annual testing (Cloud version only)	A1.3, A2.2, A2.4	Choose a paddock on the farm where the quality of the network is acceptable, even if this means compromising on the distance to pasture, and slightly modifying the use case

4.4. SIP3 Execution Plan

SIP name	SIP coordinator(s) Contact Info
SIP 3: Detection of Colorado Potato Beetle infection	Theodoros Chalazas theodoros.chalazas@ilvo.vlaanderen.be

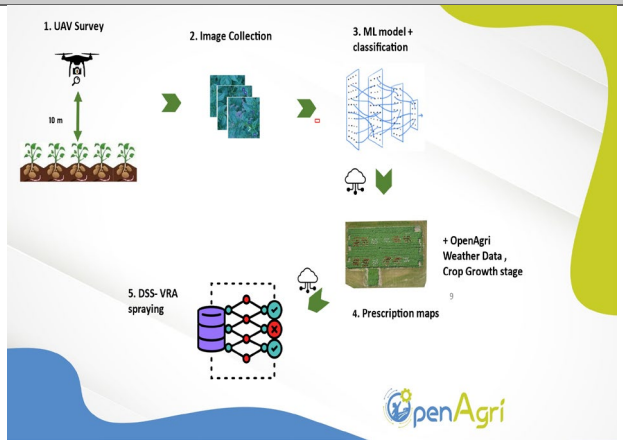
SIP GENERAL INFORMATION	
SIP sector(s)	Arables/Potatoes
Agri-food sector	Pest management
Geographical coverage (Country/ Region)	(Belgium/ Flanders)
SIP Partners	EV ILVO (SIP Leader, ADS) / ISP (Farmers and Advisors)
Farmers & Advisors involved	ISP will involve Boerenbonds' advisors and farmers in co-creating and testing the solutions. The same will be done by EV ILVO, through its Agrifood Technology Living Lab.
SIP Challenge (Need/Problem)	Farmers in Flanders face significant challenges due to the Colorado Potato Beetle (Leptinotarsa decemlineata). This voracious pest can rapidly infest potato crops, causing substantial damage if leave unchecked. Its resilience to many conventional pesticides adds complexity to control efforts, often necessitating repeated applications or the use of alternative, sometimes less effective, treatments. Additionally, the beetle's ability to develop resistance to chemicals further compounds the issue, requiring farmers to constantly adapt their pest management strategies. The economic impact of Colorado Beetle infestations can be severe, leading to reduced yields and increased production costs. Furthermore, the presence of this pest can limit market access for affected crops due to quality concerns. Thus, farmers in Flanders grapple with the persistent challenge of effectively managing Colorado Beetle infestations while striving to maintain profitable and sustainable agricultural practices. The SIP changed from 'Detection of late blight infection on potatoes' to detection of Colorado Potato Beetle infection. The reasoning of the change is that upon identifying late blight in potatoes, widespread curative fungicide spraying across the entire farm/field is applied. Therefore, the utilisation of prescription maps becomes redundant. This not only presents a clear drawback but also diminishes the comparative value of edge and cloud solutions, as the spraying planning would be the same across both scenarios. In the Colorado Potato Beetle (Leptinotarsa decemlineata) scenario, prescription maps will have a vital role in the respected ADSs.
ADS Overview	This ADS is tailored to address the specific challenge of detecting and managing the Colorado Potato Beetle (Leptinotarsa decemlineata) infestation in potato crops across Flanders. Leveraging a UAV equipped with an RGB camera, the system will scan fields to pinpoint areas affected by the beetle. Advanced AI algorithms process the collected data to precisely delineate prescription maps for targeted intervention. These maps are integrated by weather data and crop growth stage information to guide strategic response actions, such as Variable Rate Application (VRA) spraying. The outcomes generated by this ADS not only facilitate efficient pest detection and management but also enable farmers to qualify for CAP eco-schemes subsidies by providing essential monitoring, verification, and reporting capabilities. Furthermore, the system streamlines the registration of agrochemicals, ensuring compliance with regulatory standards. By specifically addressing the Colorado Potato Beetle challenge in Flanders, this ADS empowers farmers with effective tools to safeguard their crops, optimise resource utilisation, and enhance agricultural sustainability. The only

	technological adaptation during the SIP changes mentioned in the SIP challenge pertains to the camera/sensor utilised by the drone, which will transition to the High Resolution RGB camera (Sony) since Colorado beetle detection takes place in the visible spectrum. This contrasts with the previously proposed use of the Hyperspectral camera.
Other Data uses	ADS' generated data will enable a) the monitoring, verification and reporting needed to receive CAP eco-schemes subsidies and b) the registration of agrochemicals. Prescription maps will also be developed with pretrained ML algorithms. The dataset consists of images captured by UAV equipped with an RGB camera.

4.4.1. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**
EV ILVO	Technology provider	SIP Leader	Belgium/Flanders	Theodoros Chalazas (theodoros.chalazas@ilvo.vlaanderen.be)
ISP	Farmers and Advisors	Farmers and Advisors	Belgium/Flanders	Kristof Severijns (kristof.severijns@boerenbond.be)

4.4.2. Co-created ADS & Data involved in the SIP

ADS Description
This ADS is designed for addressing the Colorado Potato Beetle challenge in Flanders by integrating cutting-edge technology to enhance pest detection and management in potato crops. This comprehensive solution leverages unmanned aerial vehicles (UAV) equipped with an RGB camera to capture high-resolution field imagery. Utilising advanced image processing techniques and machine learning algorithms, the ADS plans to identify areas affected by the Colorado Potato Beetle, facilitating targeted intervention measures by generating prescription maps tailored to specific infestation zones. These maps, augmented by real-time weather data and crop growth stage information, will guide precision spraying actions for optimal pest control. The ADS architecture accommodates both cloud-based and edge/mixed scenarios, ensuring adaptability and efficiency in various deployment settings. Through its innovative approach, the ADS empowers farmers with actionable insights to mitigate the economic and agricultural impacts of Colorado Potato Beetle infestations.
Cloud based ADS Architecture
 *Figure 5 Architecture of cloud-based ADS*

The cloud scenario unfolds in two sequential steps: First, a prescription map is crafted based on carefully collected data. Second, this map transitions to the sprayer for VRA of pesticides. An advanced RGB camera is mounted on a UAV, which systematically covers the field at a height of 10 metres, capturing images. These images are then transferred to laptops via the camera's SD card or directly through cloud storage. Utilising pre-trained ML algorithms, the images are processed to generate prescription maps. Additionally, the potential of cloud computing will be thoroughly explored and evaluated for this task. These prescription maps will be seamlessly integrated with the OpenAgri Farm Calendar, Weather Data, and degree days from WP2. This integration will enable the optimal organisation and precise application of VRA spraying, targeting specific zones affected by the Colorado Potato Beetle (Leptinotarsa decemlineata).

Maturity of the ADS	Current TRL	TRL Goal [M36]
	5	7

Edge/Mixed based ADS Architecture

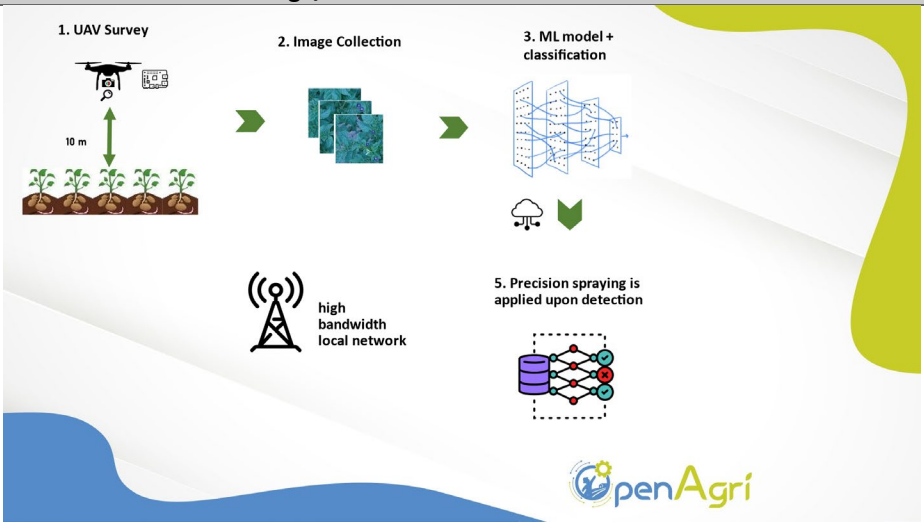


Figure 6 Architecture of edge-based ADS

In the edge/mixed scenario, image analytics are conducted close to real-time using a combination of an edge processing device and an on-premises data centre, facilitated by a high bandwidth local network temporarily installed for UAV missions. Precision spraying is implemented upon detection. Similar to the cloud scenario, an RGB camera (same sensor) is mounted on the UAV. The UAV may either be a different model with RTK connection or have an RTK GPS mounted for precise positioning in the edge/mixed scenario. Additionally, an edge processing device, such as a Raspberry Pi 4 or NVIDIA edge device, will be mounted on the drone. An on-premises data centre, portable and easy to deploy, utilising a high bandwidth local network, will also be temporarily installed for UAV missions. The UAV again covers the field at a height of 10 metres, capturing images. Initial image processing occurs on the edge device on the drone to identify zones affected by the Colorado Potato Beetle (Leptinotarsa decemlineata). Subsequently, the UAV conducts new flights around the identified zones at a lower altitude for increased accuracy and resolution. The new images are then transferred to the on-premises data centre via the high bandwidth local network for further processing. Utilising pre-trained Machine Learning (ML) algorithms, more accurate and higher resolution prescription maps are generated. These new prescription maps guide the VRA spraying, with the potential examination of an edge processing device on the VRA sprayer. In this scenario, the OpenAgri Farm Calendar, Weather Data, and degree days from WP2 are utilised for initial deployment planning.

Maturity of the ADS	Current TRL	TRL Goal [M36]
	5	7

OpenAgri OS services used

ADS data will be integrated with the Farm Calendar, Weather Data, degree days and the AI model for identifying Colorado Potato Beetle infection will be integrated with the Pest Management service.

OS Software &/or Hardware developed

The image dataset that will be collected for the development of the SIP will be provided open-source through a dataset repository. Also the source code of the Colorado beetle identification model which will be developed during the SIP will be provided as open-source.

Current Design of the ADS

Devices/ Equipment	Raspberry pi 4 or NVIDIA edge device for drone and sprayer processing, UAV (DJI Matrice 600 Pro) for cloud scenario, DJI Matrice 350 RTK for edge scenario, RGB camera (Sony), 4G modem, external RTK GPS, raspberry pi back to drone

Operating System	Operating system: Microsoft Windows for laptops, Ubuntu for Nvidia edge device Communications: WiFi: Used for communication between the UAV and the on-premises data centre and/or Raspberry Pi. 4G connection Prescription map on the cloud to spraying machine 3-4g network connection USB: Utilised for connecting the RGB camera to the UAV or Raspberry Pi for data transfer. TCP/IP: For data transmission over the network between edge and cloud components.
Power Source	Drone Battery: Powers the UAV during flight operations for data collection. Drone battery is also used for powering the GPS and Camera. Laptop Battery: Provides power to the laptop used for data analysis and system monitoring during field operations.
Energy Consumption	Battery Monitoring Systems: Monitoring the voltage, current, and temperature of batteries during operation to estimate energy consumption. Differentiation between the battery levels. Power Metres: Shelly Energy metering for measuring energy on the laptops Shunt energy metre measuring energy on external battery connected on the drone for the camera. (energy consumption during flight) Measure energy consumption in watt-hours (Wh). Manufacturer Specifications: Referring to the specifications provided by manufacturers for each device to estimate their power consumption under different operating conditions.

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
Image Analytics	Images captured by UAV equipped with RGB camera	Images	JPEG, PNG, RAW
Positioning	RTK GPS	Asci	NMEA Message Structure
Environmental data	Temperature data, weather data (weather station at ILVO, degree days, precipitation, service incorporated to the SIP from WP 2)	Numerical data	csv
Farmer's activities calendar	pesticides applications (service incorporated to the SIP from WP 2)	csv	JSON data object modelling an array of data.

4.4.3. Activities & Milestones

Activity No. 1	**Start month**	M05	**End month**	M36
Activity title	Co-Creation of Cloud and Edge/ Mixed based ADSs			
Activity goal	This activity is focused on collaboratively developing and deploying cloud and edge/mixed-based approaches of the ADS to enhance the detection and management of Colorado Potato Beetle infections. It will involve the following sub-activities:			
Activity description	**A1.1 Preparation and analysis [M05-M07]:** During this phase, the team will conduct a comprehensive analysis of data requirements, hardware specifications, and communication protocols. This includes identifying the optimal deployment strategy for combining cloud and edge computing, as well as analysing existing data sources to inform the development process. **A1.2 Community engagement for ADSs co-creation [M08-M36]:** This sub-activity focuses on engaging Boerenbond's advisors and farmers and ILVO's Agrifood Living Lab in Flanders in the co-creation and testing of the SIP3 ADSs. By involving these key stakeholders, the aim is to ensure that the solutions are tailored to the specific needs and challenges faced by farmers in the region.			

	A1.3 Deployment and development [M09-M36]: This phase encompasses the iterative deployment and development of the ADSs over three iterations. Each iteration will span accordingly, allowing for comprehensive testing and refinement of the system's performance. **A1.3.1** 1st version of the Detection of Colorado Potato Beetle (cloud and mixed/edge approach) [M09-M14] During this iteration, the initial deployment of the ADS solutions will occur based on the preparation and analysis done in A1.1 focusing on establishing baseline performance metrics and identifying areas for improvement. Operational procedures will be refined based on real-world field tests, and any hardware or software issues encountered will be addressed promptly. Existing image datasets will be used for the initial ADS development. **A1.3.2** 2nd version of the Detection of Colorado Potato Beetle (cloud and mixed/edge approach) [M15-M25] The second iteration will build upon the lessons learned from the first deployment and testing, with a focus on implementing optimizations and enhancements to improve system effectiveness. New image data will be collected for the detection of Colorado Beetle and AI algorithms will be fine-tuned, communication protocols will be optimised, and power management strategies will be refined to maximise efficiency. Continuous monitoring and feedback collection will inform ongoing improvements to the ADSs. **A1.3.3** Final version of the Detection of Colorado Potato Beetle (cloud and mixed/edge approach) [M24-M36] In the final phase, the ADSs will undergo further refinement and optimization based on feedback gathered from previous deployments and testing. Any remaining issues or challenges will be addressed to ensure the system is prepared for long-term operation. Training and support materials will be developed to assist end-users in effectively utilising the deployed solutions. This structured and iterative approach ensures thorough testing and optimization of the ADS solutions for real-world agricultural applications. The project team will develop the final version of the ADSs based on findings and recommendations from the second annual cycle of testing, incorporating all refinements and improvements identified throughout the project. The ADSs will then be prepared for deployment in operational agricultural settings, marking the culmination of the project. **A1.4 Development of Open-Source hardware/software [M08 - M36]:** This sub-activity focuses on the images collection during iteration 2 of the development process and the development of the ML algorithms which will take place during all three iterations. **A1.4.1** Data collection during 2nd Annual Cycle Testing [M26 – M34]: The RGB camera mounted on UAV during testing will be capturing image data dataset for making the ML algorithms more accurate. **A1.4.2** Release of a Pre-Final Version of the AI models [M34 – M36]: The dataset will be shared through an appropriate repository and final version of the Colorado beetle detection model through its code source. **A1.5 Integration of the OpenAgri OS services to the ADS [M09 - M35]:** The integration of the OpenAgri OS services will be done during all three iterations. ADS data will be integrated with the Farm Calendar, Weather Data, degree days and the AI model for identifying Colorado Potato Beetle infection will be integrated with the Pest Management service. **A1.5.1** Testing services within the 1st Annual Cycle Testing [M15 – M24]: After the 1st annual cycle testing the drawbacks of the solution will be reported with the partners involved in order to update if needed. **A1.5.2** Testing services within the 2nd Annual Cycle Testing [M25 – M35]: Testing the same services based on the previous work done.
Participants involved	Leader: EV ILVO; Participants: ISP, AUA, GSC GR
Milestones ***(Related to Activity 1 or Sub Activities)***	

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Comprehensive analysis	A1.1	Identification of the optimal deployment strategy	M6
2	Co-Creation with Stakeholders	A1.2	Stakeholder feedback and collaboration	M36
3	1st version of ADS	A1.3.1	Testing and validation of ADSs for Iteration 1	M14
4	2nd version of ADS	A1.3.2	Testing and validation of ADSs for Iteration 2	M25
5	Final version of ADS	A1.3.3	Testing and validation of ADSs for Iteration 3	M36
6	Data collection on the second field trial	A1.4.1	Image collection during the second iteration	M34
7	Release of Open pre-Final Version AI models	A1.4.2	Upload of the pre final version of the AI model	M36
8	Testing services	A1.51	Testing and Services during the 1st Annual Cycle Testing	M24
9	Testing Services	A1.5.2	Testing and Services during the 2nd Annual Cycle Testing	M35

Activity No. 2	**Start month**	M05	**End month**	M35
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two growing seasons, aiming to evaluate the efficiency, performance and usability of the ADSs based on the established metrics.			
Activity description	This activity is focused on the pilot trials and testing. Following a dual comparison approach, the two approaches (cloud and edge/mixed) of the co-created ADS will be compared against each other to identify the most appropriate solution for each setting. The results of the pilot trials will be documented in annual evaluation reports, which will provide a clear and objective assessment of the ADSs. It will focus on the following sub-activities. **A2.1 Selection of the Testing fields to test the 2 ADS developed in the SIP [M05 – M09]:** Selection of the testing fields with potato crops within the EV ILVO infrastructure. Strategy development to identify either beetles or damage to the leaves from beetles or both. Strategy development for beetles in the development and testing phase e.g. large nets on certain potato crops to introduce a few beetles or introduction of artificial 3d printed beetles. **A2.2 Design the testing phase for the ADSs [M09 – M14]:** During this phase, the project team will design a comprehensive testing plan for the initial version of the ADSs (iteration 1) developed in the project. This includes identifying testing objectives, defining test scenarios and specifying testing methodologies. The testing phase will be designed to assess the functionality, reliability, scalability, and usability of the ADSs in real-world agricultural environments. **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** Conduct the piloting and testing activities to perform the dual comparison of the two ADS at the field. Following the project iterative approach, the activities will take place in two annual cycles. The work is split into the following sub-activities. **A2.3.1 1st Annual Cycle Testing [M15 – M21]:** The ADSs will be deployed in agricultural fields for the first annual cycle of testing. This testing phase aims to evaluate the performance of the ADSs in detecting and managing Colorado Potato Beetle infections. During this testing phase, the efficiency, performance, and usability of the ADSs will be rigorously evaluated based on predefined metrics established in T3.1. Data collection will encompass various aspects, including the accuracy of pest detection, user satisfaction, and system reliability. Pilot trials will utilise field testing sites representative of agricultural landscapes across Flanders, ensuring the comprehensive evaluation of the ADSs' functionality.			

	Based on the collected data, the project team will compile and complete the first SIP performance report. The report will document the findings and outcomes of the first annual cycle of testing, including the performance of the ADSs, challenges encountered, and lessons learned. The report will also outline recommendations for further development and refinement of the ADSs based on the results of the testing phase. **A2.3.2 2nd Annual Cycle Testing [M25 – M33]:** The ADSs will undergo a similar testing with A2.3 for the second annual cycle. This testing phase aims to validate improvements made to the ADSs and assess their performance under different operational scenarios. The focus will be on validating the enhancements and refinements made to the ADSs following the insights gathered from the initial testing phase. This will involve deploying the systems across diverse agricultural settings and operational scenarios to evaluate their performance under varying conditions. Key aspects include assessing scalability, compatibility, and integration with existing systems. Stakeholder engagement will remain pivotal, with end-users providing feedback to inform further refinements. **At the end of this phase**, the project team will compile and complete the final SIP performance report. The report will summarise the findings and outcomes of the second annual cycle of testing, including the performance of the ADSs and any additional insights gained. The report will also provide a comprehensive overview of the entire project, including achievements, challenges, and recommendations for future work.
Participants involved	Leader: EV ILVO; Participants: ISP, AUA, GSC GR

Milestones

(Related to Activity 2 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Selection of testing fields	A2.1	Selection of the testing fields with potato crops	M09
2	Design the testing phase	A2.2	design a comprehensive testing plan for the initial version of the ADSs	M14
3	1st Annual Cycle Testing	A2.3.1	Successful deployment of ADSs in testing fields	M21
4	1st SIP Performance report	A2.3.1	1st SIP Performance report	M24
5	2nd Annual Cycle Testing	A2.3.2	Successful deployment of ADSs in testing fields	M33
6	Final SIP Performance report	A2.3.2	Final SIP Performance report	M35

Activity No. 3	**Start month**	M06	**End month**	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is primarily focused on promoting the results and findings of the SIP to various stakeholders. This activity aims to disseminate information about the project's outcomes through different channels such as social media, participation in industry-specific events, open day events, webinars, and video testimonials. **A3.1. Posts on social media and participation in industry specific events [M06 – M36]:** Throughout the duration of the project, the team will regularly publish engaging and informative posts on social media platforms (e.g., Twitter, LinkedIn, Facebook) to showcase the progress, achievements, and outcomes of the SIP. These posts will include updates on project activities, highlights of key milestones, insights from project partners, and relevant news in the field of agricultural technology. The goal is to maintain visibility, engage with stakeholders, and raise			

	awareness about the project's results to support their exploitation beyond the project's completion. Additionally, participation in industry-specific events, including conferences, seminars, webinars, both live and digital, will allow the team to present research findings, discuss technological advancements, and network with professionals in agricultural technology. This approach is complemented by participating in major agricultural and technology fairs and exhibitions, engaging directly with farmers, advisors, policymakers, and the public, and gathering valuable feedback for system refinement. **A3.2. Organise an Open Day [M24 – M36]:** In the final stages of the project, the team will organise an Open Day event to provide stakeholders, including farmers, policymakers, industry representatives, and the public, with an opportunity to learn about the SIP results firsthand. The event will feature presentations, demonstrations, and interactive sessions showcasing the ADSs, their functionalities, and their potential impact on agricultural practices. The Open Day will serve as a platform for networking, knowledge exchange, and discussions on opportunities for further collaboration and exploitation of the project outcomes. **A3.3. Create one video testimonial [M24 – M36]:** Throughout the project, the team will produce a video testimonial featuring testimonials and feedback from project partners, stakeholders, and end-users. The video will highlight the benefits, successes, and impacts of the SIP, showcasing real-world examples and experiences. Interviews, case studies, and demonstrations will be incorporated to provide compelling narratives and evidence of the project's value and effectiveness. The video testimonial will serve as a powerful tool for dissemination, promotion, and advocacy, contributing to the exploitation and sustainability of the project results beyond its conclusion. **A3.4. Organise SIP webinar [M24 – M36]:** During the final stages of the project, the team will organise a comprehensive webinar focused on sharing the results, insights, and lessons learned from the SIP with a wide audience. This webinar will be conducted virtually, allowing participants from diverse backgrounds, including researchers, practitioners, policymakers, and stakeholders, to attend remotely. The webinar will feature presentations by project partners, experts, and stakeholders, covering various aspects of the project, such as the development and deployment of ADSs, challenges encountered, best practices, and potential applications in agricultural settings. **A3.5 Community Engagement Workshops for Co-Designing ADS [M06-M36]:** This sub-activity fosters community involvement in ADS development. P2PLab will lead two workshops to train SIP partners on participatory engagement practices and create a working group that includes farmers, farm advisors, and tech startups. The aim is to co-develop community outreach and integration protocols, leading to major co-design kickstart events and successive workshops. These activities aim to develop at least five new community-driven, open-source ADSs that are socially inclusive, responsible, and sustainable.
Participants involved	Leader: EV ILVO; Participants: ISP, AUA, GSC GR, FSH

Milestones

(Related to Activity 3 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Successful Organization of Open Day Event	A3.2	Event attendance records, feedback from participants, documentation of event activities.	M36
2	Successful organisation of the SIP webinar	A3.4	Webinar attendance records, feedback from participants.	M36
3	Completion of Video Testimonial	A3.3	Finalised video testimonial ready for dissemination	M36
4	Completion of Community Engagement Workshops	A3.4	Workshop attendance logs, workshop training materials,	M36

			reports on workshop outcomes, documentation of co-developed ADS protocols and designs	

4.4.4. Dissemination & Demonstration activities

Dissemination & Demonstration activities				
Activity	**Chanel Type**	**Frequency**	**Targeted audience group**	**Dissemination materials**
Create social media posts and spread them through the partners' accounts and the OpenAgri accounts.	Social Media	At least 8 during development and demonstration.	All	Pictures from the field, stories, other material
One Open Day will be launched to demonstrate the SIP results on the field.	Demonstration Events	Once in the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	A video showcasing the 2 ADS describing their benefits and presenting the results.
Organise one webinar testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	Presentation of results, insights, and lessons learned from the SIP with a wide audience

4.4.5. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	SIP 3 will use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	SIP 3 will release the source code as OS, together with the validation data sets.
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	2	Farmers, Advisors and Stakeholders from Boerenbond and EV ILVO Agrifood Living Lab.
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	EV ILVO will host one Open Days in the ILVO facilities demonstrating the two ADSs.
Open Day Participants	Number of people participating in the Open Days	0	50	The Open Days should have at least 20 participants
Social Media Posts	Number of Social Media post	0	8	SIP 3 will do at least 8 posts regarding the development and demonstration of the SIP.

Video testimonials	Number of Video testimonials created.	0	1	SIP 3 will create 1 video testimonial with the help of WP4 partners.

4.4.6. Evaluation & Comparison metrics

Effectiveness and Performance in Agriculture Scenarios

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 11 - Evaluation metrics for effectiveness and performance in agriculture scenarios for SIP3

No	Metric	Notes
1	**Accuracy of ML models (Colorado Beetle detection)**	**Cross-Validation:** Perform cross-validation techniques (e.g. k-fold cross validation) to evaluate the accuracy of ML models in both versions. Cross-validation helps ensure that the models generalise well to unseen data and provides a robust estimate of their performance. **Testing on Diverse Data:** Test models on diverse datasets captured from various locations to ensure robustness. Testing on diverse datasets is essential to validate the models' robustness across different scenarios and environments. **Comparison with Ground Truth:** Compare model predictions with ground truth annotations to measure accuracy metrics. Comparing model predictions with ground truth annotations is crucial for assessing the models' accuracy and reliability in detecting potato blight.
2	**Speed/time needed to complete detection and spraying**	**Benchmarking:** Benchmark the processing speed of both edge and cloud solutions for different dataset sizes. Benchmarking the processing speed of both versions allows for a direct comparison of their performance under different workload conditions. **Real-Time Performance:** Assess the real-time performance of both versions from image capture to detection and spraying. Assessing real-time performance from image capture to detection and spraying provides insights into the practical usability and responsiveness of each version.
3	**Production cost efficiency**	**Cost Analysis:** Conduct a comprehensive cost analysis considering infrastructure costs, hardware costs, energy consumption, and maintenance expenses for both edge and cloud solutions. **Scalability Consideration:** Evaluate the scalability of both versions concerning cost implications as the system expands. This will help assess their long-term viability and scalability potential.

Computing Resource Utilization and Energy Efficiency

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 12 Evaluation metrics for computing resource utilization and energy efficiency for SIP3

No	Metric	Notes
1	**Networking resources** utilisation for data transmission for the two scenarios.	This metric evaluates data transmission needs on captured images from UAV that are sent for further processing to a cloud system against processing in a local system.
2	**Computing resources** utilised for image processing in the two scenarios.	This will be evaluated against different levels of accuracy for the ML models for Colorado beetle detection.

3	**Total energy consumed for data processing and data transmission**	Measure the energy consumption of both cloud and edge solutions during operation. Use energy monitoring tools or power metres to collect accurate energy usage data. Measuring the energy consumption of both versions during operation provides valuable data for evaluating their efficiency and identifying areas for optimization.
4	**Total energy consumed for completing the farming operation.**	This will include energy calculated in metric 3 in combination with the energy required for performing the overall task of pest management. e.g. in edge/mixed based approach, there will be more flying in different altitudes after identifying infected zones for better resolution. The energy needed for releasing more flights will be considered.

Comparison Metrics Overview

Table 13 SIP3 Comparison Metrics

SIP3 Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Time to Detection	Measures the time taken from image capture by the UAV to the identification of infested areas with Colorado Potato Beetle.	Average time from data capture to pest detection across all trials.
Accuracy of ML models	This metric evaluates the accuracy of ML models for Colorado beetle detection through the methodologies mentioned in the Effectiveness and Performance in Agriculture Scenarios section.	Improved accuracy metrics derived from cross-validation, testing on diverse data, and comparison with ground truth annotations, providing a comprehensive evaluation of ML model performance for Colorado beetle detection.
Production Cost Efficiency	Conduct a comprehensive cost analysis considering infrastructure costs, hardware costs, energy consumption, and maintenance expenses for both edge and cloud solutions. Evaluate the scalability of both versions concerning cost implications as the system expands. This evaluation aids in assessing their long-term viability and scalability potential.	Enhanced understanding of production cost efficiency through detailed cost analysis and scalability assessment, facilitating informed decision-making regarding edge and cloud solutions.
Computing & network resources utilisation and energy efficiency		
Computing Resources Utilised for Image Processing in the Two Scenarios	This metric evaluates the computing resources used for image processing against different levels of accuracy for the ML models for Colorado beetle detection.	Amount of data transmitted (in GB) to the cloud vs. data processed locally, along with the bandwidth usage and transmission time
Computing Resources Utilised for Image Processing in the Two Scenarios	This metric evaluates the computing resources used for image processing against different levels of accuracy for the ML models for Colorado beetle detection.	CPU/GPU usage, processing time, and accuracy levels of ML models in both cloud and local systems.
Total Energy Consumed for Data Processing and Data Transmission	Measure the energy consumption of both cloud and edge solutions during operation. Use energy monitoring tools or power meters to	Total energy consumption (in kWh) for data processing and transmission in cloud vs. local systems.

	collect accurate energy usage data. Measuring the energy consumption of both versions during operation provides valuable data for evaluating their efficiency and identifying areas for optimization.	
Total Energy Consumed for Completing the Farming Operation	This includes the energy calculated in the previous metric combined with the energy required for performing the overall task of pest management. For example, in an edge/mixed-based approach, there will be more flying at different altitudes after identifying infected zones for better resolution. The energy needed for releasing more flights will be considered.	Total energy consumption (in kWh) for the entire farming operation, including data processing, transmission, and additional UAV flights for pest management.
Use of Standards / Interoperability and Switchability		
Evaluation of Data Standards and File Formats	Analysis of data modelling approaches, standardisation mechanisms, barriers, and benefits.	List and short report analysing data modelling and standardisation mechanisms.
Evaluation of Networking/Communication Standards	Analysis of technical specifications of networking/communication standards, including barriers and benefits.	List and short report analysing telecom and IoT communication protocols.
Switchability of Software Modules	Evaluation of the potential to reuse software services in different contexts using containerization technologies.	Report analysing reusability of software modules with containerization technologies (e.g., Docker).
Switchability of Farm Data Collections	Evaluation of the feasibility of retrieving and reusing farm data collections with solutions from different providers.	Report analysing reusability of farm data collections.
Switchability of Hardware Modules	Evaluation of the potential to reuse hardware services in different contexts, focusing on plug and play mechanisms and hardware protocols.	Report analysing reusability of hardware modules.

4.4.7. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**
Potential Delays in Development and Deployment	All activities	1. Regular monitoring of project progress and milestones to identify potential delays early on. 2. Allocation of additional resources or adjustment of timelines in case of unforeseen delays. 3. Prioritisation of critical tasks to ensure timely completion.

		4. Clear communication and collaboration among team members to address issues promptly.
Uncertainty in Technology Integration	A 1.3	1. Thorough testing of technology components individually and in integration to identify and address compatibility issues early in the development process. 2. Collaboration with technology vendors and experts to ensure seamless integration and interoperability of hardware and software components. 3. Continuous monitoring of technological advancements and updates to incorporate the latest developments into the project.
Stakeholder Resistance or Lack of Engagement	A3	1. Early and ongoing engagement with stakeholders to understand their needs, concerns, and expectations. 2. Tailoring communication and engagement strategies to different stakeholder groups to ensure relevance and effectiveness. 3. Providing clear and compelling evidence of the benefits and impacts of the project to encourage stakeholder buy-in and support. 4. Creating opportunities for stakeholders to actively participate in project activities, such as co-creation workshops and feedback sessions.
Unforeseen Weather Conditions	A1 and A2	1. Continuous monitoring of weather forecasts to anticipate potential disruptions and plan fieldwork accordingly. 2. Implementation of flexible scheduling to accommodate changes due to weather conditions.
Equipment Malfunction	A2	1. Regular maintenance and calibration of field equipment to prevent malfunctions during demonstrations and testing. 2. Carrying backup equipment or spare parts to quickly address any technical issues that may arise on-site. 3. Training field personnel on proper equipment usage and troubleshooting procedures to minimise the impact of malfunctions.
Data Loss or Corruption	A2	1. Implementation of robust data backup procedures to prevent loss or corruption of valuable fieldwork data. 2. Regular data synchronisation and transfer to secure storage systems or cloud platforms to minimise the risk of data loss. 3. Training field personnel on proper data handling and storage practices to prevent accidental deletions or unauthorised access.

4.5. SIP4 Execution Plan

SIP name	SIP coordinator(s) Contact Info
SIP4 – Open hardware smart irrigation controller with management system	Radosław Taraciński, PSNC rtaracinski@man.poznan.pl

SIP GENERAL INFORMATION	
SIP sector(s)	Crop, Arable/Sugar beet and Potatoes
Agri-food sector	irrigation, from sowing/planting to harvest
Geographical coverage (Country/ Region)	Poland, Greater Poland
SIP Partners	Poznan Supercomputing and Networking Center (PSNC), Łukasiewicz - Poznań Institute of Technology (L-PIT), Wielkopolska Agricultural Advisory Center (WODR)
Farmers & Advisors involved	TOP FARMS Group Wielkopolska, Exhibition and Training Center WODR in Sielinko (talks with additional farmers are underway)
SIP Challenge (Need/Problem)	The challenge is to reduce water use on (first) high-production farms, where water use per hectare of crops is highest, using smart irrigation controllers. The challenge particularly applies to arable and vegetable production. The water needs of plants (in SIP4 we consider case of sugar beets and potatoes crops) must be met at several key moments in the growth of the plant, so as not to restrict the development of the root system, during the period of highest weight growth, to preserve the health of the plant during the period of disease development and before harvest (quality preservation). From year to year, the variability of the period and number of rainfall (up to 50%) and the multi-year increase in temperature (global climate change) cause large differences in crop yields, which affects the regions' food security. Particularly vulnerable is the Greater Poland region where the effects of desertification are already occurring and where the amount of precipitation in successive years is reduced which results in increased irrigation, lowered groundwater levels and affects the biosystem of watercourses (from birds and fish to microorganisms). There is a lack of widely available easy-to-implement systems for controlling the amount of crop watering. Under current conditions, on-machine control of watering is based on setting the time and rate of watering without automatically taking into account analysis of rainfall, evapotranspiration and water needs of plants. The system under development, in addition to the open hardware solution, also allows taking into account the above variables and additional optimization of doses taking into account evaporation, temperature effects and soil type, which we can obtain from external datasets: weather stations, soil maps, weather forecasts. Smart controller will also be able to cooperate and exchange data with agroERP systems, allowing for full management of crops and their costs. The main Final user involved in the project is one of Top Farms' farms with 28 reel sprinklers, 3,200 hectares of sprinkler network coverage and effectively irrigating 800 hectares per year. As part of the project, we anticipate testing on other farms as well. The system will also be feasible for smaller farms. For a production company generating 85,000 tons of potatoes per year (Top Farms, 2019), a 10% reduction in water use will save money, have a sustainable environmental impact and maintain quality in line with the Global G.A.P. and IFA (Integrated Farm Assurance Standard) certification.

	We also plan tests for the irrigation system belonging to the Exhibition and Training Center WODR in Sielinko. This type of irrigation has a significantly different design compared to reel sprinklers, but the control of solenoid valves and irrigation doses in general will not differ significantly. This will allow us to prepare solutions for the two most important types of field irrigation.
ADS Overview	The ADS provides an easily accessible and universal smart irrigation controller, connected to irrigation valves, capable also of integrating with soil moisture sensors and FMISs/agroERP systems It enables automated irrigation of the fields, allowing for the optimisation of the doses using data on the evapotranspiration, rainfall, water needs of plants, temperature effects and soil type, which will be obtained both from connected soil moisture sensors and from external datasets: weather stations, soil maps, weather forecasts and satellite data. The ADS will be consulted and tested with a diverse group of users (different size of farms).
Other Data uses	Data is used to document the sustainable irrigation practices, and thus the farmer can obtain sustainable producer certification (GLOBAL G.A.P.) potentially resulting in higher price for crops.

4.5.1. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**
Poznan Supercomputing and Networking Center (PSNC)	Technology provider	SIP Leader, ADS Provider	Greater Poland / Poland	Radosław Taraciński rtaracinski@man.poznan.pl
Łukasiewicz - Poznań Institute of Technology (L-PIT)	Technology provider	Partner, ADS Provider	Greater Poland / Poland	Tomasz Markowski tomasz.markowski@pit.lukasiewicz.gov.pl
Wielkopolska Agricultural Advisory Center (WODR)	Advisor	Partner, ADS Provider	Greater Poland / Poland	Anna Rzeszutko anna.rzeszutko@wodr.poznan.pl
TOP FARMS Group (https://topfarms.com/)	Farmer	Farmers	many regions of Poland /Poland	office@topfarms.pl
Agri Solutions (https://agrisolutions.eu/about-us)	Tech provider	Consulting in data management	Lower Silesian Voivodeship/ Poland	kontakt@agrisolutions.eu
Łukomet (https://www.lukomet.pl/en/o-nas-r72)	Tech provider	Consulting in the field of irrigation in fields, integrator of electronic solutions on sprinklers	Masovian Voivodeship/Poland	lukomet@lukomet.pl
inVentia (https://www.inventia.pl/)	Tech provider	Consulting in the field of irrigation algorithms; probable supplier of soil moisture sensors	Masovian Voivodeship/Poland	inventia@inventia.pl

4.5.2. Co-created ADS & Data involved in the SIP

ADS Description
The ADS prepared as part of SIP4 is primarily intended to prepare modifications for existing older types of reel sprinklers, without any electronics. As part of the open hardware concept, IoT electronics will be prepared, allowing for the control of water valves and communication with nearby soil moisture sensors. Communication will be provided via the LoRa (LoRaWAN) protocol. Main device being developed will be a smart irrigation controller, which will communicate with soil moisture sensors and with cloud servers via LoRa gateway and both transmitting and receiving data from and to the server. Soil moisture sensors, as the name suggests, will provide soil moisture data at a depth of several centimetres (exact depth to be determined during prototype development) at various points on the irrigated field. The main device itself or the soil moisture sensors will also be equipped with further, environmental sensors that can be used to obtain needed data and calculate evapotranspiration, such as: solar radiation, air temperature and humidity. Approach in the edge version will process data locally without the need for constant connection to the cloud. Work on the irrigation algorithm will begin by implementing the simplest version - if the soil moisture in a specific point of a farm field drops below a set threshold, turn on the water solenoid valve for a specified amount of time, watering with a specific dose. In the cloud version, decision making will be enriched by datasets which will be processed using learning AI algorithms, having access to, among others: satellite data (e.g. soil maps, NDVI maps), data from meteorological stations (wind speed and air temperature), phenological stations, historical data (eg. accumulated precipitation for the last months), weather forecast etc. Information about the shape of fields (geodetic data) and the type of crop could be entered into the system manually or from other agricultural platforms/services developed by PSNC in cooperation with WODR (https://www.edwin.gov.pl/). All this will allow for the most optimal selection of irrigation doses.   *Figure 7 Reel sprinkles* The figure below shows the concept of modernising and equipping the drum sprinkler with additional elements. We assume that the main part (marked in green) of the sprinkler with the water connection will be stationary. There will be a water solenoid valve there. Due to the highest current consumption due to the solenoid valve control, a battery with a relatively large capacity will have to be located there. We assume that there will be soil moisture sensors in the nearby area. As the irrigation tip changes position, various sensors will be within its range. All communication of these IoT devices will be done using LoRa.

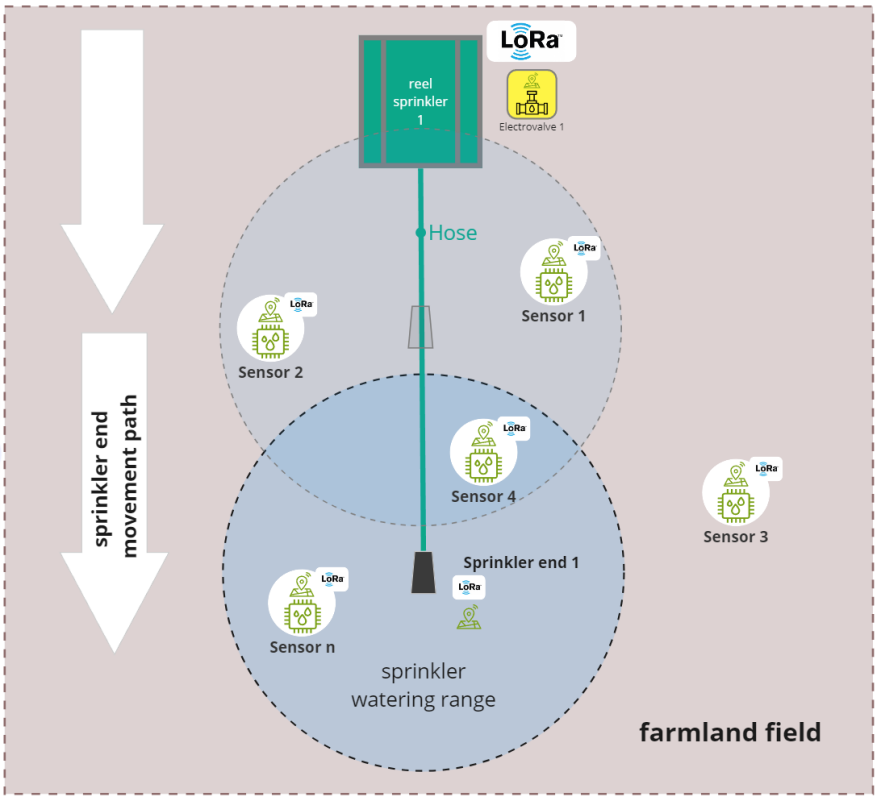


Figure 8 Case 1 - reel sprinkler with mobile sprinkler end

The second type of sprinkler device we consider modifying or adapt within SIP4 is an irrigation system shown on Figure 3. Even though it is quite large (spanning up to several hundred metres), conceptually it is much simpler than a single reel sprinkler.

Figure 9 Irrigation systems

Similarly, when the entire system moves, it "encounters" subsequent soil moisture sensors. Figure below presents the concept of an irrigation system - analogous to the concept with reel sprinklers.

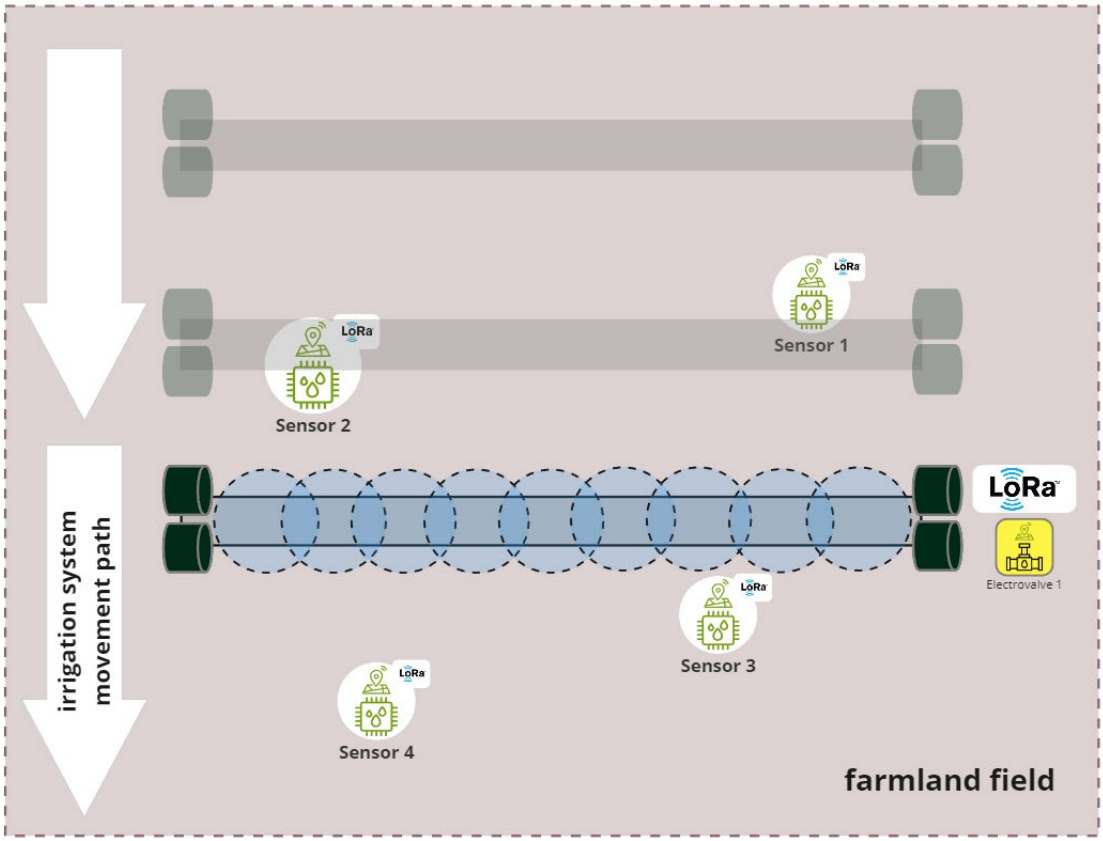


Figure 10 Case 2 - mobile irrigation system

Next diagrams showing two (slightly different) concepts of system architecture will be presented below. The first one shows the cloud version. The second one is the mixed/edge version.
In both versions, the diagram consists of two parts. On the left side there are elements of the system that are in the fields: sprinklers with additional water valve control, soil moisture sensors connected by LoRa. The right side presents the backend part with all the components used.
One difference is in the middle part. In the cloud version there is TheThingsNetwork LoRaWan infrastructure used. In the mixed/edge version, there is a need to replace the TTN infrastructure with some own local e.g. ChirpStack.

Cloud based ADS Architecture

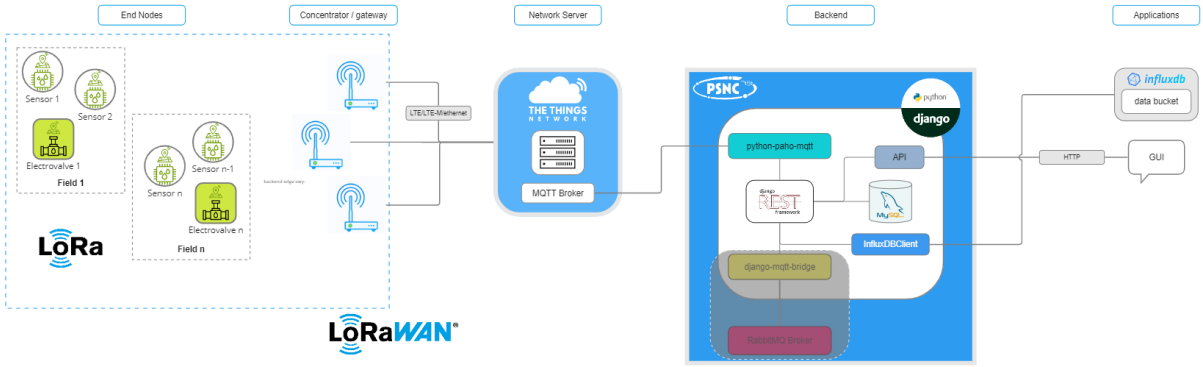


Figure 11 Cloud based ADS Architecture (whole picture)

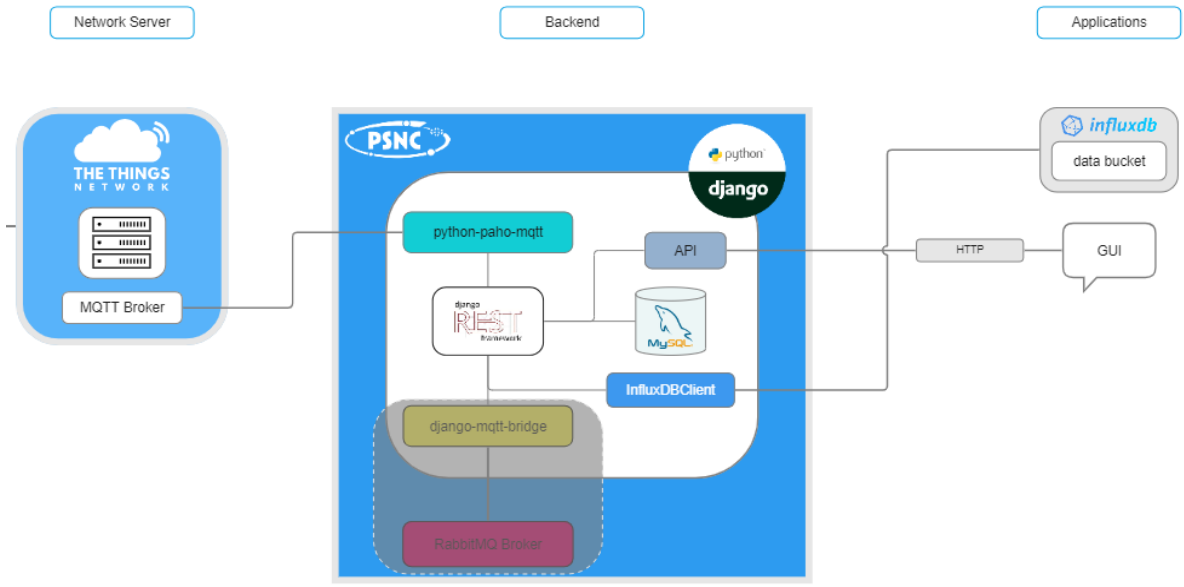


Figure 12 Cloud based part ADS Architecture - right part of picture

The cloud solution will be based on many different available data sets, but especially on data from meteorological stations and weather forecasts delivered within eDWIN project (https://www.edwin.gov.pl/dane-Agrometeorolo giczne). The implementation of the cloud solution is expected to result in reduced water consumption due to the anticipated rainfall.

The right part of the diagram depicts a cloud-based LoRaWAN solution using a set of open tools and global, open network that provides maximum security and is ready to scale – The Things Network. Edge devices communicate with The Things Stack Servers, transmitting data (uplink) and receiving messages (downlink) from user applications in the service. PSNC provides backend services and connects them to TTN via MQTT Broker. The backend is implemented in Python and is built in Django web framework, extended with REST services with Django REST framework. The backend utilises a local database (MySQL) to store edge devices: metadata such as unique in TTN Lora device name and EUI, configurations and status. Local database serves as a buffer for recently captured sensor data from the edge. Collected from edge data flow through backend and with Python InfluxDB Client, is written to a time-series data database. PSNC backend exposes API that can be integrated with additional services: for data display or remote system management using mobile or web applications.

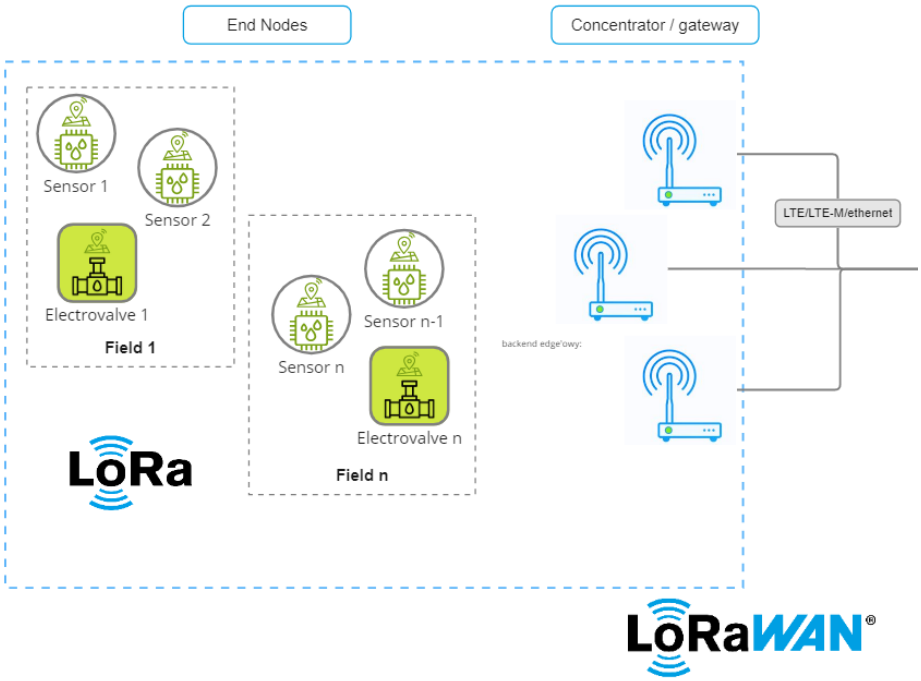


Figure 13 Cloud based part ADS Architecture - left part of picture

The left side is the edge infrastructure part. Concentrators/gateways are responsible for the data flow between edge devices and the cloud. The edge devices on the end node include sensors and electrovalves located in specific agricultural fields. Each edge device is equipped with a LoRa device. Gateways transmit data to the cloud (The Things Stack servers) using LTE/LTE-M or Ethernet networks. On the end node side, there are no computations performed, only the data forwarding process.

Maturity of the ADS	Current TRL	TRL Goal [M36]
	TRL6	TRL8

Edge/Mixed based ADS Architecture

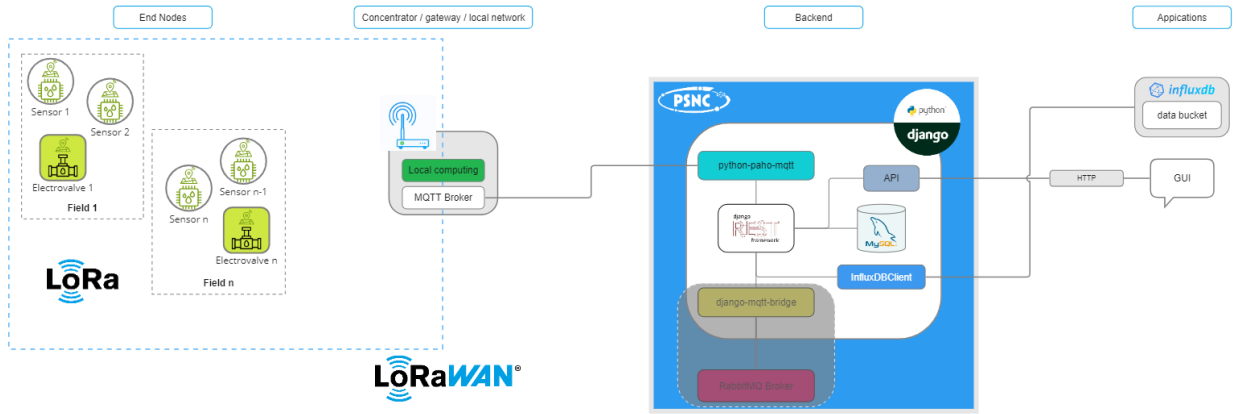


Figure 14 Edge/mixed based ADS Architecture (whole picture)

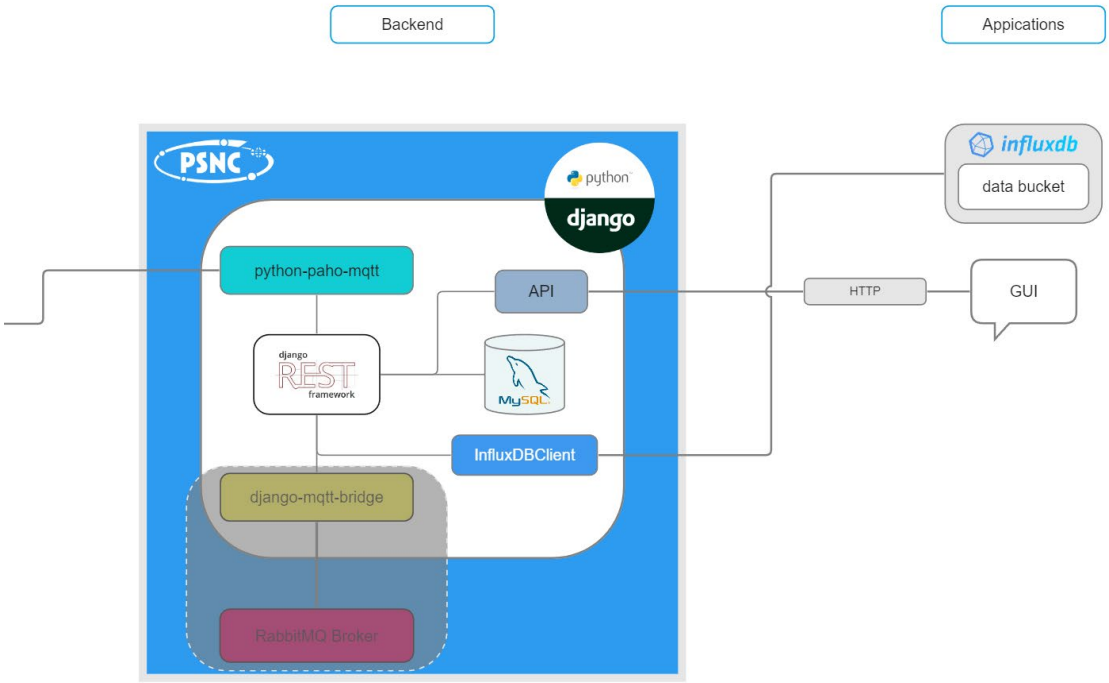


Figure 15 Edge/mixed based ADS Architecture - right part of the picture

The edge/mixed solution by using soil sensors, will show the exact soil moisture, but could cause higher water consumption compared to cloud solution. The improvement of the edge algorithm will be achieved by conducting a comparative analysis of these two solutions.

The right part of the diagram illustrates a cloud-based LoRaWAN solution without The Things Network infrastructure. It is essentially the same as the previous concept of cloud-based architecture, except PSNC connects to MQTT brokers created on the edge and utilises open-source local solutions, such as ChirpStack

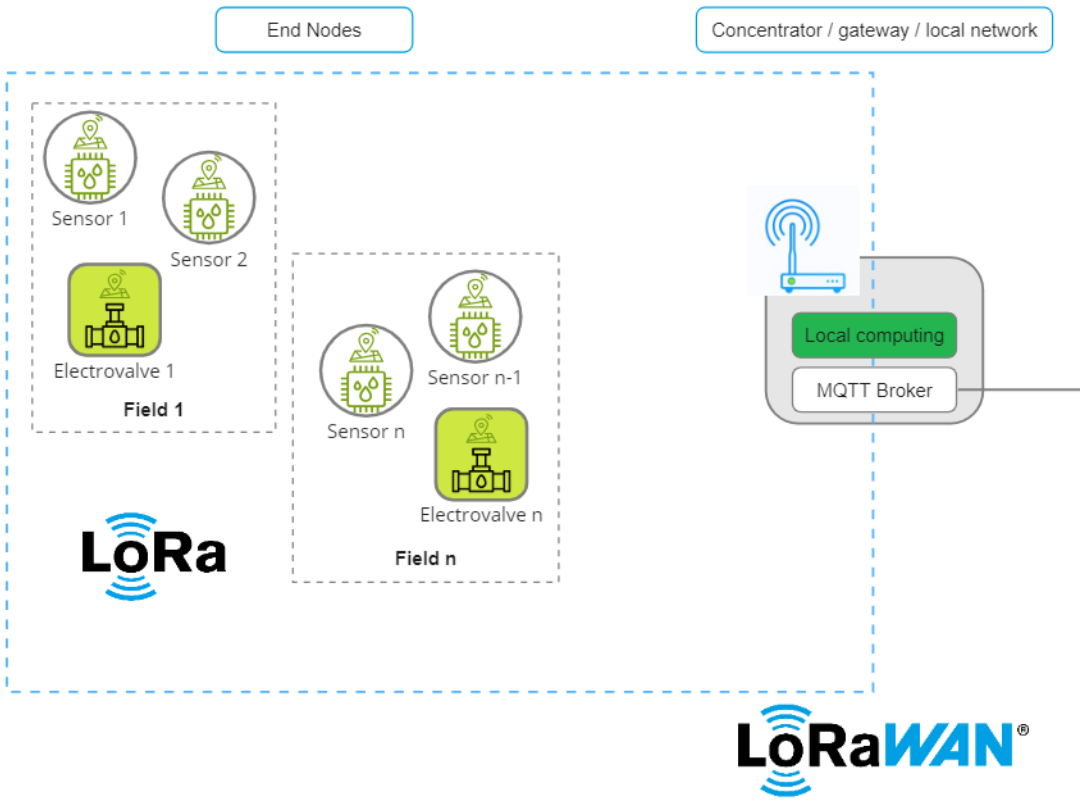


Figure 16 Edge/mixed based ADS Architecture – left part of the picture

The edge part remains the same, but there are differences in the data flow from end node devices to the PSNC backend. Additionally, the edge will encompass some computing on local machines, including a gateway for LoRaWAN. Moreover, the edge device will establish an MQTT broker for communication with the cloud.

Maturity of the ADS	**Current TRL**	**TRL Goal [M36]**
	TRL4	**TRL8**

OpenAgri OS services used

From presented by WP2 OpenAgri OS services, which will be developed, we would like to take advantage of it and integrate the following:

- Irrigation service,
- Weather Data Service,
- Reporting service,
- Digital Farm Calendar.

Due to the main goal of SIP4, i.e. improving the quality and efficiency of irrigation, it will be necessary, first, to cooperate with the team developing the "Irrigation service". It should be cooperation, because work done during developing and improving SIP4 and experience gained by the team, will affect the result of this OS service. On the other hand, toolkit or useful calculators that support decision making on irrigation management, can improve and can be used for comparison of algorithms developed by the SIP4 team.

To prepare and improve the watering algorithm and making it more accessible for implementation in other countries, it will also be important to integrate with the "Weather Data Service", which allows to obtain current and historical data about e.g. temperature, rainfall. It will be possible to mark irrigation dates using the "Digital Farm Calendar".

OS Software &/or Hardware developed

As a result of the work in SIP4, a smart irrigation controller will be created. It is planned to equip it with the following functionalities:

- universal and easy adjustable and connectable to existing devices (reel sprinklers and irrigation systems) on market,
- It has to allow physical connection to irrigation solenoid valves,
- Geospatial data tagging with GNSS modules,
- decision making that could be both based on a combination of simple logic rules (e.g. soil moisture is below a predefined threshold) or more complex using calculation of evapotranspiration,
- energy autonomous with limited (or not at all) connectivity and use of cloud servers,
- open-source embedded system based on Linux,

- LoRaWAN mesh for wireless communication.

It will be necessary to find on the market or, if needed, design a new suitable soil moisture sensor that will have the following features:

- obtaining the value of soil moisture,
- reliable, corrosion resistant,
- geospatial data tagging with GNSS modules
- connection to network of other sensors and (nearest/dedicated) smart irrigation controller,
- Inductive class of sensors with digital data output,
- energy autonomous with limited (or not at all) connectivity and use of cloud servers (equipped with battery or solar panel.

Low-level control software must be created for both types of devices. The software presented earlier in the diagrams will also be created to capture data from LoRa and transmit it to servers and send back appropriate decisions regarding irrigation (in the cloud/mixed version).

Current Design of the ADS	
Devices/ Equipment	ADS will utilise the LoRaWAN gateway to The ThingsNetwork in a cloud/mix solution and a Raspberry SBC in an edge solution. Humidity sensors and valve actuators will be integrated with a LoRaWAN communication module built on STM32 microcontroller.
Operating System	Operating system of a gateway is based on the open source Linux family OS. LoRaWAN communication modules will operate on developed in the OpenAgri project open-software solution. Communication between gateway and sensors and actuators will be conducted by LoRaWAN protocol. Connectivity to the internet will be based on the GSM network. Communication between gateway in a cloud solution will be based on a Bluetooth connection to the smartphone of the user.
Power Source	Sensors and actuators will be powered by battery and ready to integrate with solar panels. LoRaWAN will be powered from a static power source with optional integration with solar panel and battery source.
Energy Consumption	Energy consumption will be calculated after the development of sensors and actuators.

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
Environmental data	Temperature (min., average, max), Humidity (min., average, max), Total precipitation, Wind speed (min., average, max) Soil moisture, Luminosity	Numerical data	JSON
Device status and position data	Battery voltage, Current on the solenoid valve, GPS coordinates of system elements,	Numerical data	JSON
Cultivation related	crop type, Parcel's coordinates, irrigation type, number of plants per hectare	Textual/numerical descriptions	JSON
Farmer's activities calendar	day of planting, day of harvesting, growth (phenological) stages, performed irrigations	Textual/numerical descriptions	JSON
LoRa/LoRaWAN Metadata	Information about specific device: device EUI (Extended Unique Identifier)	Textual/numerical descriptions	JSON

4.5.3. Activities & Milestones

Activity No. 1	Start month	M03	End month	M36
Activity title	Co-Creation of Cloud and Edge/ Mixed based ADS			
Activity goal	To deploy and operate a complete prototype of an irrigation system and conduct tests in 2024 season.			
Activity description	This activity is focused on developing a concept of the entire system and then a prototype that can be tested in the current 2024 season. It will focus on the following sub-activities. **A1.1 Preparation and analysis [M03 – M05]:** During this phase the identification of existing reel sprinklers used by TOP FARMS, irrigation system owned by the WODR Exhibition and Training Centre in Sielinko, will take place in order to determine the needs of the centre's employees related to irrigation of the surrounding fields. The last action will be identifying farmers potentially interested in cooperation in SIP4. **A1.2 Community engagement for ADSs co-creation [M03 – M13]:** Cooperation with other interested participants/stakeholders, such as developers of sensors, irrigation solutions, agricultural software. In the beginning, it is necessary to check current state of the art in the field of modern irrigation, in the field of used electronics and software. Next step will be contact with companies creating software related to agriculture and determining their needs, as well as with developers of soil moisture sensors, trying to interest all of them in SIP4. **A1.3 Deployment and operation [M09 – M36]:** This sub-activity will encompass the iterative deployment and development of the ADSs over three iterations. Each iteration will span accordingly, allowing for comprehensive testing and refinement of the system's performance. **A1.3.1** 1st version of the ADS (cloud and mixed) [M09 – M14]: The first version of the ADSs for software and hardware for both approaches will be ready for deployment. **A1.3.2** 2nd version of the ADS (cloud and mixed) [M22 – M25]: Drawing from the results of the initial round of pilot trials, we will identify the limitations of both solutions. This will enable us to implement any necessary software or hardware enhancements for the two solutions. **A1.3.3** Final version of the ADS (cloud and mixed) [M34 – M36]: The preparation of the final version of ADS will result from collecting experience from previous years and proposing final changes and improvements in both hardware and software. It will be necessary to prepare the final technical documentation in the field of hardware and software, which would be made available in open-source form. Next step will be preparation of manufacturing documentation and producing ready-made devices. **A1.4 Development of OS software/hardware [M03 – M36]:** This activity is focused on development and final creation of both Open-Source hardware and software for smart irrigation systems. It will focus on the following sub-activities. **A1.4.1** Data collection during 1st Annual Cycle Testing [M15 – M21]: The current state of the art in the field of electronics used for irrigation systems and of software used for irrigation management along with previous projects in which PSNC participated will be determined. The best electronics platform for prototype development (e.g. Raspberry Pi, Arduino, ESP) will be selected by the Hardware team. Additional PCBs or ''hats'' for e.g. Raspberry Pi or Arduino will be designed, if need be. The next step regarding software is selection and subsequent approval of elements included in the cloud software architecture. This will allow the preparation of prototypes: of web application and mobile application. Attempts at integrations with the eDWiN system by PSNC and with OpenAgri OS services will be prepared. After completing the previously described steps, preparation of the first iteration of prototypes for the 2024 season will be possible. **A1.4.2** Data collection during 2nd Annual Cycle Testing [M26– M34]: The second iteration of prototypes, testing in the L-PIT laboratory and then in the field on reel sprinklers belonging to ''TOP FARMS'' group and on an irrigation system belonging to WODR Exhibition and Training Centre in Sielinko will be during season 2025. Additionally, conclusions from the 2024 season in terms of software functionality and reliability will be drawn. This will allow for the preparation of a system prototype for the 2025 season, then conducting tests of the working system and finally for drawing conclusions. **A1.4.3** Release of a Pre-Final Version of OS [M34 – M36]: Same as for previous year, lessons should be learned and corrections made for the next iteration of the prototype, for season 2026. Then, producing the third, final prototype, testing it in L-PIT laboratories and on the fields. And drawing conclusions again, this time final ones, summarising 3 years of work. These described			

	activities will also take place for the 2026 season allowing for drawing final conclusions, summarising 3 years of work. **A1.5 Integration of the OpenAgri OS services to the ADS [M09-M35]:** This activity is focused on the integration of Irrigation service, Weather Data Service, Reporting service and Digital Farm Calendar with the software developed by PSNC. It will focus on the following sub-activities. **A1.5.1** Testing services within the 1st Annual Cycle Testing [M09 – M24]**:** Once the main software development work has been carried out, it will be possible to start testing the integration of each service. Cooperation with WP2 for support and tips regarding OpenAgri OS services and share of comments/feedback. **A1.5.2** Software Updates [M22 – M25]: Software updates and in the OS services will be done based on the report on the previous testing. **A1.5.3** Testing services within the 2nd Annual Cycle Testing [M25 – M35]: Testing the same services based on the previous work done.
Participants involved	Leader: PSNC; Participants: L-PIT), WODR

Milestones
(Related to Activity 1 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Initiation of SIP4 operations	A1.1	Generating internal reports/meeting minutes	M03
2	Completion of identification of reel sprinklers and irrigation systems	A1.1	Preparation of a internal report on technical identification of devices	M05
3	Completing the identification of additional participants/stakeholders who may have an impact on SIP4	A1.2	Preparation of an internal report about participants/stakeholders	M08
4	1st version of ADS	A1.3.2	1st Version of the Viewer ready for deployment	M14
5	2nd version of ADS	A1.3.3	Software and hardware updates based on the reports from A2.4	M25
6	Final version of ADS	A1.3.4	Preparation of manufacturing documentation and ready-made devices	M36
7	Data collection on the first field trial	A1.4.1	Collection of SOTA for electronics used for irrigation systems and of software used for irrigation management	M21
8	Data collection on the second field trial	A1.4.2	Functional software and electronics system prototype	M34
9	Release of Open pre-Final Version AI models	A1.4.3	Upload of the pre final version of the OS	M36
10	Integration of OpenAgri OS services with the ADS	A1.5	Services integrated with the Viewer	M12
11	Testing services with the ADS	A1.5.1	Testing and Services during the 1st Annual Cycle Testing	M24
12	Software Updates	A1.5.2	Software Updates in the VIewer/OS services	M25
13	Testing Services with the ADS	A1.5.3	Testing and Services during the 2nd Annual Cycle Testing	M35

Activity No. 2	Start month	M05	End month	M35
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two growing seasons, aiming to evaluate the efficiency, performance and usability of the ADSs based on the established metrics.			
Activity description	This activity is focused on effective establishment of cooperation with SIP4 interested partners and conducting effective field tests. It will focus on the following sub-activities. **A2.1 Selection of the Testing fields to test the 2 ADS developed in the SIP [M05 – M09]:** Establish cooperation with ''TOP FARMS'' and with WODR Exhibition and Training Centre in Sielinko. It will also be important to establish and start cooperation with other farmers interested in SIP4 (ongoing). After these steps, selection of fields for the first tests both for 2024 and especially 2025 growing seasons will be necessary. **A2.2 Design the testing phase for the ADSs [M12 – M14]:** Actual testing of the first prototype of the entire system will begin in the 2025 season, so in the beginning drawing conclusions from the 2024 season (internally, in SIP4 team) will be essential. Conversations with farmers providing test fields and determining their expectations for the next season will be conducted. Important will be determining the crop calendar for the 2025 season. **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** Conduct the piloting and testing activities to perform the dual comparison of the two ADS at the field. Following the project iterative approach, the activities will take place in two annual cycles. The work is split into the following sub-activities. **A2.3.1 1st Annual Cycle Testing [M15 – M21]:** Testing of the first complete version of ADS will take place in 2025. This means that improvements to the hardware and software to the 2024 version will need to be made. Then it will probably be necessary to make new prototypes. Once completed, it will be possible to conduct field tests in the 2025 season. We assume continuous collection of feedback from farmers providing test fields. First tests will be conducted in the L-PIT laboratory, then tests of electronics prototypes will take place in the field (season 2024), on reel sprinklers belonging to “TOP FARMS'' group and on an irrigation system belonging to WODR Exhibition and Training Centre in Sielinko. Conclusions will then be drawn from the 2024 season in terms of electronics functionality, which will cause introducing changes to the prototype of devices for the 2025 season. **Based on the collected data** the first SIP performance report will be completed based on the KPIs that were defined. An internal collection of experience (lessons learned) from prototype tests (hardware and software) conducted in season 2025. It will be necessary to collect experience from prototype tests from farmers providing test fields and as well suggesting changes and improvements in both hardware and software. **A2.3.2 2nd Annual Cycle Testing [M25 – M34]:** Testing of the second complete version of ADS will take place in 2026. This means that improvements to the hardware and software to the 2025 version will need to be made. Then it will probably be necessary to make new prototypes. Once completed, it will be possible to conduct field tests in the 2026 season. We assume continuous collection of feedback from farmers providing test fields. **At the end of this phase,** the final report will include the results of the second phase of testing and an overall analysis of the performance of each mode (cloud and edge) of the solution. An internal collection of experience (lessons learned) from prototype tests (hardware and software) conducted in season 2026. It will be necessary to collect experience from prototype tests from farmers providing test fields and as well suggesting changes and improvements in both hardware and software.			
Participants involved	Leader: L-PIT (hardware), PSNC (software); Participants: L-PIT, WODR, other stakeholders: farmers involved and technical solution providers			

Milestones

(Related to Activity 2 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Selection of testing fields	A2.1	Signing cooperation agreements	M09
2	Design the testing phase	A2.2	Preparing a note/report and presenting it on the SIP4 team forum and eventually sharing it with WP3	M14

3	1st Annual Cycle Testing	A2.3.1	End of the 2025 season with harvest, preparing a note/report and presenting it on the SIP4 team forum and sharing it with WP3	M21
4	1st SIP Performance report	A2.3.1	1st SIP Performance report	M24
5	2nd Annual Cycle Testing	A2.3.2	End of the 2026 season with harvest, preparing a note/report and presenting it on the SIP4 team forum and sharing it with WP3	M33
6	Final SIP Performance report	A2.3.2	Final SIP Performance report	M35

Activity No. 3	**Start month**	M06	**End month**	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is focused on showing the development done in SIP4 and promoting the OpenAgri project. It will focus on the following sub-activities. **A3.1. Monthly posts on Social media [M06 – M36]:** This sub activity will start with getting to know the work in progress and reviewing arrangements in WP4. Thanks to this, posts describing the progress of work in SIP4, will be prepared. It should be noted that before publishing materials, it is advisable to obtain approval from the person responsible for official OpenAgri social media. Then the posts will be published on consortium members (PSNC, L-PIT, WODR) social media: internal newsletters, Twitter (X), Facebook, LinkedIn. **A3.2. Organise an Open Day [M24 – M36]:** In the beginning it is necessary to collect information about all appropriate fairs/exhibitions taking place (primarily) in Poland and then selecting the best fair/exhibition where it is possible to organise a presentation of the operation of the entire system on a demonstration field. **A3.3. Create one video testimonial [M24 – M36]:** That task should start with establishing guidelines from those responsible for WP4. Next steps will be: script preparation, selection of scenes and appropriate demo fields, recording scenes at the right moments of plant growth, film editing. Then it will be necessary to submit the edited film for approval and wait for instructions on possible corrections. After that, sending the film for approval in WP4, publishing the video on social media and finally presenting the film at agricultural exhibitions/fairs. **A3.4 Community Engagement Workshops for Co-Designing ADS [M06 – M36]:** This sub-activity fosters community involvement in ADS development. P2PLab will lead two workshops to train SIP partners on participatory engagement practices and create a working group that includes farmers, farm advisors, and tech startups. The aim is to co-develop community outreach and integration protocols, leading to major co-design kickstart events and successive workshops. These activities aim to develop at least five new community-driven, open-source ADSs that are socially inclusive, responsible, and sustainable.			
Participants involved	Leader: L-PIT, PSNC; Participants: L-PIT, PSNC, WODR			

Milestones
(Related to Activity 3 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Posting a certain number of posts on social media	A3.1	Reaching the minimum required number of posts	M33
2	Organise Open Day	A3.2	Presenting SIP4 results at a specific exhibition/fair	M33
3	Preparation of the final version of the Video testimonial	A3.3	Sharing the approved version of the video on social media	M33

4	Completion of Community Engagement Workshops	A3.4	Workshop attendance logs, workshop training materials, reports on workshop outcomes, documentation of co-developed ADS protocols and designs	M36

4.5.4. Dissemination & Demonstration activities

Dissemination & Demonstration activities				
Activity	**Chanel Type**	**Frequency**	**Targeted audience group**	**Dissemination materials**
Create social media posts and spread them through the partners' accounts and the OpenAgri accounts.	Social Media	Once every month.	All	Pictures from the field, stories, other material
One Open Day will be launched in 2025 or 2026 to demonstrate the SIP results on the field.	Demonstration Events	Once in the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	A video showcasing the 2 ADS describing their benefits and presenting the results.
Exhibiting at fairs/exhibitions	Agricultural fairs, exhibitions	Any interesting fairs/exhibitions in the near or distant area	farmers interested in modern irrigation and agriculture 4.0 in general; IoT sensor manufacturers	roll-up, leaflets

4.5.5. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	SIP4 will result with creation of 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	SIP4 will create both open source hardware (minimum 1 device) and software
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	1	We assume that we will interest SIP4 in at least 1 important company that deals with the development of modern irrigation systems or is a subcontractor/supplier of important elements of such a system (e.g. soil probe developers)
Dissemination				

Organised Open Days	Number of organised Open Days	0	1	SIP4 team will organise open day during specific, important agricultural fairs/exhibitions in Poland (rather in Greater Poland)
Open Day Participants	Number of people participating in the Open Days	0	10	We assume that we will interest at least 10 farmers/companies who irrigate their crops and want to benefit from the effects of our work
Social Media Posts	Number of Social Media post	0	5	SIP4 team will prepare as many published posts on social media as necessary
Video testimonials	Number of Video testimonials created.	0	1	SIP4 team will create 1 video testimonial with the help of WP4 partners.

4.5.6. Evaluation & Comparison metrics

Effectiveness and Performance in Agriculture Scenarios

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 14 - Evaluation metrics for effectiveness and performance in agriculture scenarios for SIP4

No	Metric	Notes
1	**Efficiency of irrigation**	Comparing current approach vs those developed as part of ADS (cloud and edge): Watering efficiency for existing, non-modernized equipment (reel sprinklers) will be analysed based on data obtained from farmers (especially TOP FARMS group) from the last few years. After implementing the smart irrigation controller in both versions (cloud, edge), it will be possible to compare watering efficiency with the previous, non-optimized approach. We expect to experience lower water consumption using our solutions (especially the cloud solution). Comparing cloud vs edge: The main difference between cloud and edge solutions will be access to additional data. In the edge solution, irrigation will be controlled according to rigid assumptions regarding the appropriate soil moisture and limiting or increasing the frequency and/or dose of water within the adopted hysteresis of the soil moisture level. In the case of the cloud solution, the irrigation control algorithm will be enhanced with weather data, including predictions of weather changes based on meteorological services, in addition to soil moisture data. Therefore, the irrigation hysteresis will be able to be modified based on predictive data and not only current and static data. The effectiveness of both solutions will be measured by the amount of water used for irrigation and the obtained soil moisture level, therefore its stability over time.
2	**Performance of the ML optimisation algorithm**	The effectiveness of machine learning algorithms will be assessed by analysing the stability of the set soil moisture level over time. Adjustments to the irrigation schedule and doses will be evaluated based on soil moisture data from field sensors and weather forecasts from meteorological services. This evaluation will focus on analysing the trends in achieving optimal soil moisture levels. The effectiveness of weather condition predictions can also be evaluated by comparing them with data from environmental sensors.
3	**Reduction in manual labour/effort needed**	This metric aims to measure the reduction in manual labour required for irrigation management and monitoring tasks following the implementation of edge/mixed and cloud-based ADS. Initially, the total hours of manual labour needed for these tasks will be recorded to establish a baseline. After deploying the ADSs, the same tasks will be monitored to determine the new amount of manual labour required. The primary objective is to quantify the efficiency gains by comparing the pre- and post-implementation labour hours, thereby

		illustrating how many manual activities have been replaced with automated ones. The effectiveness of the automation will be expressed as a percentage reduction in manual labour. This is calculated by taking the difference between the baseline manual labour hours and the post-implementation hours, divided by the baseline hours, and then multiplied by 100. For instance, if the initial manual effort is 100 hours per month and post-implementation it reduces to 40 hours, the reduction percentage would be 60%. This metric provides a clear indication of how automation impacts labour requirements, highlighting the benefits of ADS in enhancing operational efficiency in irrigation management.

Computing Resource Utilization and Energy Efficiency

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 15 Evaluation metrics for computing resource utilization and energy efficiency for SIP4

No	Metric	Notes
1	**Networking resources** utilisation for data transmission for the two scenarios.	For the cloud-based solution data collection from multiple sources will be realised (pre-processed satellite data: soil type maps, NDVI maps, meteorological stations: wind speed, air temperature; weather forecasts etc.). In the edge/mixed model only local soil moisture sensor data as well as other local data needed to calculate evapotranspiration (solar radiation, air temperature and humidity) are expected to be collected.
2	**Computing resources** utilised for data processing in the two scenarios.	Irrigation doses will be the result of ML algorithms and for both cases the performance of the ML in extracting the proper/accurate irrigation dose will also be considered. Cloud based ADS processing will include pre-processed satellite data, soil type maps, insolation, crop type, growth stage and weather conditions. In the edge/mixed model the pretrained decision support algorithm will run autonomously on the irrigation controllers with limited computing power, having access only to local sensor data. PSNC resources: including cloud services, computing power and data storage, will be used.
3	**Total energy consumed for data processing and data transmission**	Calculation of consumed energy for specifying the irrigation dose.
4	**Total energy consumed for completing the farming operation.**	Calculation of consumed energy for specifying the irrigation dose (metric 3) and also energy consumed from the actual irrigation activities.

Comparison Metrics Overview

Table 16 – SIP4 Comparison Metrics

SIP4 Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Efficiency of irrigation	Irrigation water consumption per square meter of field and the obtained soil moisture level.	Reduction of the water consumption per square meter of field (at least a 10% reduction in water use).

Performance of the ML optimisation algorithm	Comparison between the current, unmodernized approach to irrigation the one developed in subsequent and final version of ML algorithm.	Reduction of the total water consumption per irrigated field (at least a 10% reduction in water use).
Reduction in manual labour/effort needed	Comparison between the current, unmodernized approach and those developed within ADSs (edge/mixed vs cloud) in terms of manual labour/effort needed.	Percentage decrease in manual labour hours related to irrigation activities.
Computing & network resources utilisation and energy efficiency		
Networking resources utilisation for data transmission for the two scenarios.	Measures data transmission volumes and efficiency in both edge/mixed model and cloud-based scenarios.	Total amount of data transmitted
Computing resources utilised for data processing in the two scenarios.	Evaluates computational load for sensor data processing in edge/mixed vs computational load for sensor data extended by external data sources (e.g. weather stations, satellites data) in cloud scenarios.	SoC (*system-on-chip*) usage in edge/mixed solution, HPC (*High-performance computing*) usage in cloud solution
Total energy consumed for data processing and data transmission	Calculates the energy used in data processing and transmission activities.	Power consumption measured for both scenarios
Total energy consumed for completing the farming operation.	Includes the energy calculated in the previous metric combined with the energy consumed by operating solenoid valves for opening/closing water flow	Power consumption measured for both scenarios
Use of Standards / Interoperability and Switchability		
Evaluation of Data Standards and File Formats	Analysis of data modelling approaches, standardisation mechanisms, barriers, and benefits.	List and short report analysing data modelling and standardisation mechanisms.
Evaluation of Networking/Communication Standards	Analysis of technical specifications of networking/communication standards, including barriers and benefits.	List and short report analysing telecom and IoT communication protocols.
Switchability of Software Modules	Evaluation of the potential to reuse software services in different contexts using containerization technologies.	Report analysing reusability of software modules with containerization technologies (e.g., Docker).
Switchability of Farm Data Collections	Evaluation of the feasibility of retrieving and reusing farm data collections with solutions from different providers.	Report analysing reusability of farm data collections.
Switchability of Hardware Modules	Evaluation of the potential to reuse hardware services in different contexts, focusing on plug and play mechanisms and hardware protocols.	Report analysing reusability of hardware modules.

4.5.7. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**
Resignation from participation by one of the farmers	A1.3, A2.1, A2.2	A reserve list of interested farmers allowing you to quickly start new cooperation
Resignation from work of one of the key members of the SIP4 team	A1.1	Meticulous keeping of publicly available notes on the progress of work and maintaining all technical documentation, sharing knowledge about the project among partners
Sudden lack of suitable electronic components (such as the problem with the availability of Raspberry Pi 4 in recent years)	A1.4	Parallel identification of other possible hardware for prototyping that is more available
Difficulty in proving that the solutions used in the SIP have achieved the intended results (reducing water consumption by at least 10%)	A2.4, A2.6	Collecting reliable, detailed data from farmers on their current irrigation; close substantive cooperation with local agricultural advisors (from WODR)

4.6. SIP5 Execution Plan

SIP name	SIP coordinator(s) Contact Info
SIP5 - IoT Assisted Organic Compost Production in Open Piles	Constantinos Loizou, EMBIO Diagnostics, k.loizou@embiodiagnostics.eu

SIP GENERAL INFORMATION	
SIP sector(s)	Vegetables (Tomatoes, Cucumber, Lettuce)
Agri-food sector	Pre-production, focusing on organic compost production for fertiliser use
Geographical coverage (Country/ Region)	Cyprus / South-East Europe
SIP Partners	EMBIO Diagnostics (SIP leader, ADS provider) GSC GR (DIH, ADS provider)
Farmers & Advisors involved	Farmers Fresh (3rd party, access to farmers, advisors, and compost experts)
SIP Challenge (Need/Problem)	Under the Green Deal umbrella, the Farm to Fork Strategy has set out a very important target of bringing 25% of the EU's agricultural land under organic farming by 2030, while decreasing the use of chemical fertilisers by >20%. Excessive fertilisation is related to various agro-environmental and health problems such as soil degradation, nitrate accumulation, and water pollution. At the same time, farmers are facing productivity pressures due the continuously increasing prices for chemical fertilisers. Replacing chemical fertilisers with organic compost produced using farm residues and by-products, would help reduce input costs, support organic production and reach Green Deal goals. In Cyprus and many other countries in the region, due to cost limitations and/or lack of digital skills, compost production takes place in open space using piles (no composting bins used) and is mainly manual. This includes both the monitoring of the compost conditions, which is limited to manual daily checks of the pile's temperature, but also the decision making and management process, including compost irrigation and stirring activities. Estimation of NPK content needs to be realised in various phases of the composting process and certain actions are necessary (e.g. provide additional material, calibrate conditions) in order to achieve a standardised Nitrogen-Phosphorus-Potassium (NPK) content. For organic compost to be effectively used as fertiliser, it is essential to have a standardised NPK content per quantity (e.g. kg). This standardisation allows farmers to control precisely the amount of each nutrient that is added to the cultivation. Calibration of NPK content requires field visits to the site of the piles, sampling of compost and chemical analysis that takes place in the lab. As it is obvious this is a laborious process increasing the financial and logistics cost.
ADS Overview	SIP5 aims to develop a low-cost, deploy-and-forget IoT-based system for monitoring compost piles and providing decision support, supporting organic fertiliser production by enhancing the efficiency of the process and reducing manual labour. For the needs of this SIP the DigiCompost ADS (created by GSC) will be adapted, extended and integrated with OpenAgri's open source services. Although this ADS can be used to support all agricultural sectors in need of organic compost, it will be trained and tested specifically to produce organic compost/fertiliser for vegetables in Cyprus. This ADS supports concurrent monitoring of multiple compost piles in remote areas through LoRaWAN and LoRA linked sensors (Temp, Moisture, pH). Data collected by the sensors are visualised in user friendly dashboards allowing the compost manager to remotely supervise the process. In addition, it provides warnings for key events (emergence of anaerobic digestion, need for aeration), and it is capable to automate mitigation actions (e.g. actuates irrigation to reduce piles temperature and/or to increase moisture).

	Compost pile's conditions monitoring will be combined with an easy-to-use portable BioElectric-chemical analysis sensor (BELD by Embio) capable of estimating NPK content of compost samples on-site and in near-real-time. The portable BELD NPK estimator is a handheld multichannel potentiometer with high accuracy A/D converters that measure electric signals (measured in Volts) from various bio recognition elements recorded as a time-series. Based on this information farmers will be able to decide on the relevant future actions, e.g., change the composition of the compost, irrigate, aerate, stop composting. This will allow us to proceed with the necessary adjustments during the composting period and to manipulate the final chemical composition of the organic fertiliser.
Other Data uses	The end-product can be accompanied by data demonstrating the manufacturing process and product characteristics (NPK) and compliance with EU Fertilising Products Regulation

4.6.1. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**
EMBIO Diagnostics Ltd (SME)	Technology Provider	SIP Leader, ADS Provider	Cyprus	Constantinos Loizou k.loizou@embiodiagnostics.eu
Green Supply Chain Digital Innovation Hub (GSC GR) (DIH)	Digital Innovation Hub, ADS Provider	Partner, ADS Provider	Greece	Nikos Kalatzis nikosk@greensupplychain.eu
Farmers Fresh (3rd Party)	Wholesaler	Access provider to farmers, advisors, and compost experts	Cyprus	Koullis Phylactou k.phylactou@farmersfresh.eu

4.6.2. Co-created ADS & Data involved in the SIP

ADS Description
The ADS for SIP5 is designed to optimise organic compost production through IoT technology. Utilising both cloud-based and edge/mixed-based approaches, it integrates IoT sensors to monitor critical compost parameters like temperature, moisture, pH and NPK. In the cloud-based framework, data is analysed on a centralised platform, allowing for remote monitoring and automated management actions. The edge approach processes data locally, reducing reliance on constant cloud connectivity and enhancing responsiveness. Both systems are integrated with OpenAgri OS services to leverage additional data for improved decision-making, supporting the EU's Green Deal objectives by making organic composting more efficient and sustainable.
Cloud based ADS Architecture
Data collection in the cloud-based ADS architecture for SIP5 is realised with the use of IoT sensors (temperature, moisture, pH) deployed across multiple compost piles. Depending on the volume of material contained in the pile the respective number of sensors will be installed. The whole design is wrapped around LoRaWAN technology which ensures data recording and transmission providing long range, low power and secure characteristics which are ideal for IoT sensing and telemetry use cases in rural areas. For the needs of SIP5 compost monitoring LoRa-based gateways are utilised that can serve multiple sensing devices over a distance of more than 15 kilometres in rural areas. IoT sensors are also based on LoRaWAN technologies operating with Li-SOCI2 batteries designed for long-term use up to 5 years.

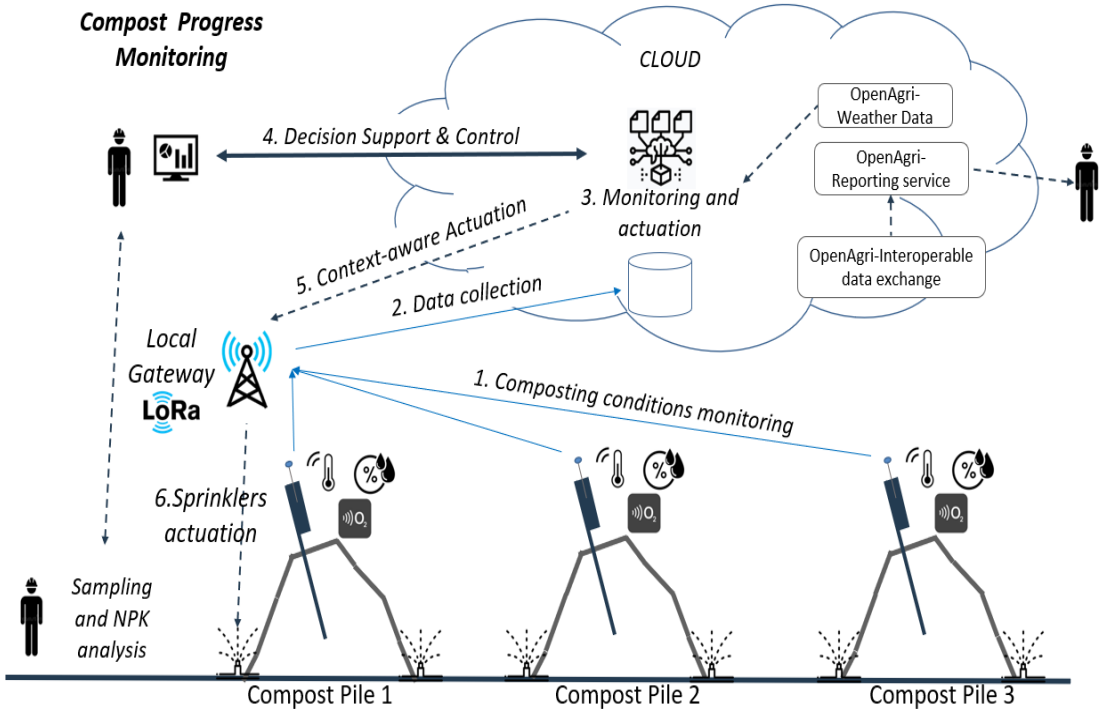


Figure 17 ADS Architecture Overview for cloud-based approach

These sensors communicate data via LoRaWAN to a local gateway, which then transmits the data using 2G/3G connectivity to a global collaborative LoRa based Internet of Things ecosystem (called TheThingsNetwork). The IoT recordings will then persist to a centralised cloud-based IoT platform (e.g. datacake.co) which is offered following the Platform-as-a-service (PaaS) paradigm. The cost for using the cloud platform is proportional with the number of sensors that are integrated. The data platform supports the specification of logical rules and conditions (e.g. if pile's X Temperature is lower than 30^0C generate alert "Temperature above limit" or actuate device). Dynamic actuation will be evaluated for the automated use of sprinklers. LoRaWAN valves will be integrated with the PaaS platform and actuation will be realised through LoRaWAN messages. Based on the outcomes of the decision support algorithm commands to the actuators (sprinklers) will be sent for activating the irrigation for a predefined time period. In addition, the PaaS will support the integration of data derived from other sources with the use of REST API.

The BELD device provides on-site, near-real-time NPK content analysis, and the results from the on-site sampling will also be uploaded and integrated along with the rest of the compost piles measurements. In the cloud-based approach the BELD measurement, the final values of the signals are uploaded to a cloud server, analysed by a pattern matching calculation algorithm where the result is compared against predefined patterns. The outcome of the process (estimated NPK content) is stored in the cloud server. Communication of the BELD NPK estimator is facilitated via Bluetooth 4.0 with a smartphone or tablet, allowing the end-user to be instantly informed of each analysis result while the actual results are also expressed as "Below" or "Above" the predefined NPK levels escorted by a confidence level expressed in %. The outcomes of the BELD measurements will also be integrated with the IoT sensor measurements stored in the PaaS. All raw data from IoT sensors and the BELD portable devices are transmitted and stored in a centralised time-series data repository of the PaaS platform. This approach is significantly increasing the volume of data transmitted and stored which results in increased use of networking and computational/storage cloud resources. These, in turn, result in significant financial cost (use of PaaS is proportional to the integrated sensors) and unnecessary technical and administrative data management burden.

Maturity of the ADS	Current TRL	TRL Goal [M36]
	5	7
Edge/Mixed based ADS Architecture		

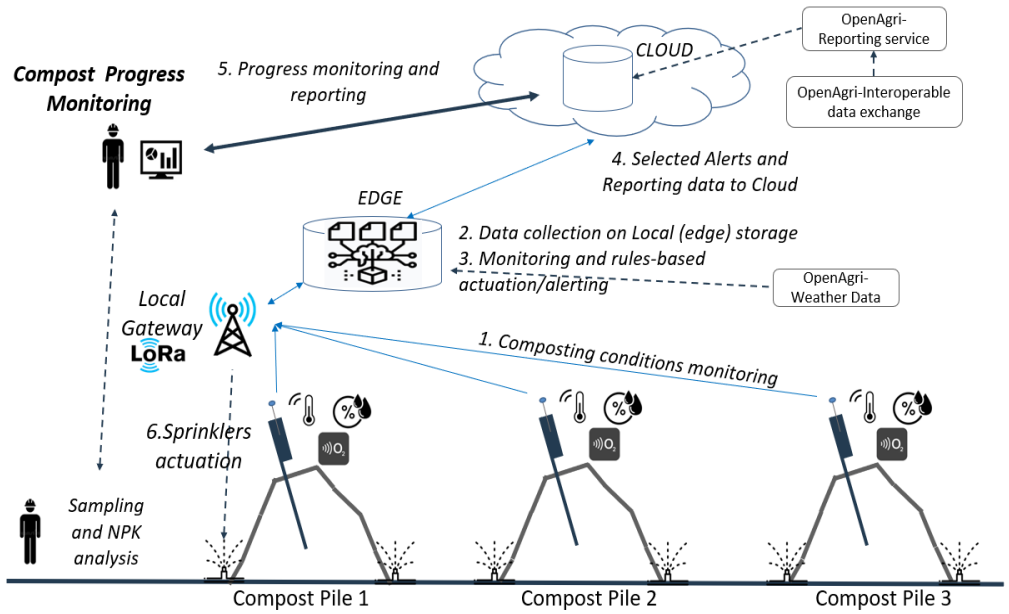


Figure 18 ADS Architecture Overview for edge/mixed approach

For the edge/mixed-based DigiCompost monitoring ADS the same type of LoRaWan sensors will be utilised. The objective of this approach will be to limit the volume of data transferred to the cloud service only to those necessary for the compost management process.

Critical alerts and aggregate data are then transmitted to the cloud for more complex processing and historical data analysis. This hybrid approach allows for real-time monitoring and actuation directly on-site, reducing reliance on continuous cloud connectivity and improving responsiveness.This will be realised with the use of a "tiny-server" (also known as a nano or micro DataCenter in Edge computing terminology) that will act as a local-regional data centre (instead of sending all measurements to Paas). Data collection and implementation of the conditional rules will be applied at the "tiny-server" that will be hosted in a computer system that will act as a LoRaWAN server and database management system hosting the required services for data collection from sensors, data storage, and decision making from multiple compost piles in the area. Only processed outcomes such as calculated aggregates, extracted decisions for actuation and alerts will be mediated to a cloud instance and made available for visualisation. In the case of BELD device processing of signals will be realised in the edge device (mobile phone) which will host light-weight versions of pretrained NPK estimation algorithms.

Maturity of the ADS	Current TRL	TRL Goal [M36]
	5	7

OpenAgri OS services used

For SIP5, we plan to integrate the following OpenAgri OS services into both our cloud-based and edge/mixed-based ADSs:

Weather Data Service: This service will be crucial for SIP5, as accurate and real-time weather data are essential for optimising the composting process. By integrating weather data from OpenWeather, ECMWF, and local weather stations, we can adjust moisture levels and predict optimal turning times for the compost piles. The service will contribute to predicting and mitigating critical conditions. For example, it will be useful to predict extreme increases in compost pile temperature in the event of an upcoming heatwave that may affect the fermentation process.

Reporting Service: Generating and managing reports are integral parts of monitoring and validating the composting process's efficiency and compliance with environmental and agricultural standards. The Reporting Service will be used to automate the generation of reports related to compost production. Automated, semi-automated, and customised reports, both human and machine-readable, will significantly reduce the administrative burden on our team, allowing us to focus more on optimising the composting process and less on paperwork.

Interoperable data exchange and Access Control Service: This reusable service will support the exchange of datasets among relevant stakeholders. For example, it will be feasible to dynamically retrieve the compost production log for a specific batch of organic fertilisers by issuing a query to the DigiCompost platform.

These OpenAgri OS services will be seamlessly integrated into our cloud and edge/mixed-based ADSs to enhance the efficiency, sustainability, and compliance of our compost monitoring and management system, ultimately contributing to the broader goals of sustainable agricultural practices and organic production.

OS Software &/or Hardware developed

The project will develop an OS DSS including training datasets for compost pile conditions and NPK content estimation. This DSS will leverage inputs from IoT sensors and the BELD device, processing data through both cloud-based and edge computing approaches for real-time decision-making.	
Current Design of the ADS	
Devices/ Equipment	LoRaWAN IoT sensors (temperature, moisture, pH), BELD device for NPK analysis, local gateways for data aggregation and edge processing.
Operating System	The cloud-based DigiCompost service will be hosted in the PaaS platform. The mixed edge/cloud is foreseen to be hosted in a Linux-based OS with the support of LoRaWAN protocols for sensor data communication and control command dissemination.
Power Source	All LoRaWAN sensors will be powered by Li-SOCI2 batteries designed for long-term use up to 5 years.
Energy Consumption	Energy consumption is optimised through the use of energy-efficient sensors and edge devices, with scheduled data transmission and sensor activation to reduce power usage. Energy consumption is monitored via the energy usage metrics of the devices, aiming for minimal consumption while maintaining real-time data transmission and processing capabilities.

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
Environmental Data	Temperature (real-time, day max, day min, day average), Humidity, Moisture content of compost, pH levels of compost, Precipitation (to assess water input from rainfall)	JSON or encode measurement for real-time data transmission and interoperability with different systems; CSV for historical data analysis and reporting.	A W3C or ETSI RDF based ontology like SOSA will be used for modelling "Environmental Data". The RDF expressions will only be used during interactions with external systems
Compost Monitoring Data	Compost pile's coordinates (location within the farm), Types of organic waste used (vegetable waste, animal manure, etc.), Turnover frequency (to ensure aeration), NPK content (measured by BELD device), Temperature and moisture content variations over time	JSON or encode measurement for real-time monitoring and alerts; CSV for detailed analysis and historical tracking.	We are not aware for an existing standard about these data types.
Agricultural Practices and Inputs	Dates of compost pile setup, expected maturation date of compost, Compost turning schedule, Amendments added (e.g., greens, browns to balance the compost mixture), Monitoring schedules (for temperature, moisture, and pH checks)	CSV for planning and record-keeping, enabling easy access and manipulation of data for farmers and advisors.	OpenAgri or Farmtopia Common Semantic model to be reused.

4.6.3. Activities & Milestones

Activity No. 1	**Start month**	M03	**End month**	M36
Activity title	Co-creation of Cloud and Edge/Mixed-based ADS			
Activity goal	This activity is focused on the joint development, initial implementation and eventual validation of both cloud-based and edge/mixed-based ADSs that monitor and manage compost conditions efficiently. It will focus on the following sub-activities:			
Activity description	**A1.1 Preparation and analysis [M03 – M06]:** This sub-activity focuses on analysing the current compost production process and documenting the full requirement for the compost monitoring ADS. The work is broken down as follows:			

	Detailing requirements for the compost monitoring ADS. This will include reviewing the regulation and identify the domain specific properties that the compost should address in order to be officially registered in the market as organic fertiliser. Analysis a) of the current compost production process and identification of the various issues that digital mechanisms can provide results in a more efficient and less labour-intensive manner and b) of technical requirements and available technologies for reuse including (LoRaWAN) sensor types, data needs, energy needs, and connectivity options considering various domain-specific properties, e.g. availability of connectivity and power options at the composting area, availability to host tiny-server systems, LoRaWAN gateways at the premises of the compost manufacturer, etc. **A1.2 Community engagement for ADSs co-creation [M08-M36]:** Identification and documentation of current composting practices (raw materials used, currently applied composting practices, market needs and potential benefits from a digital monitored composting process) will take place in this sub-activity. This will be a co-creation process and interactive engagement with stakeholders is necessary. **A1.3 Deployment and operation [M05-M36]:** This sub-activity encompasses the iterative deployment and development of the ADSs over three iterations. Each iteration will span accordingly, allowing for comprehensive testing and refinement of the system's performance. **A1.3.1** Data collection for cloud and mixed solution for the first round of trials [M05-M11]: This sub-activity focuses on deploying and operating the needed infrastructure for data collection and monitoring. Data collection infrastructure will be deployed, including LoRaWAN sensors and gateways. Additionally, data channels will be established with TheThingsNetwork and with the PaaS data platform, and finally the data visualisation dashboard will be set up. The data collection infrastructure is expected to be deployed until M11 but it will remain available until the end of the SIP5. **A1.3.2** 1st version of the ADSs [M12 – M14]: The first version of the ADS for both approaches will be ready for deployment. Initial testing will be conducted on functionality and reliability. Testing of handheld B.EL.D™ prototype for NPK sample analysis at the lab (both cloud and edge-based mode of operation). To effectively measure NPK in compost piles, we are planning to integrate Ion-Selective Electrodes (ISEs) into the B.EL.D™ device as a practical modification. These ISEs, specifically tailored for detecting nitrate, phosphate, and potassium ions, will offer precise, real-time nutrient analysis suitable for harsh agricultural environments. Sensors will be embedded into a robust monitoring system, akin to the existing B.EL.D™ setup, ensuring their protection and functionality under variable composting conditions. **A1.3.3** 2nd version of the ADSs [M22 – M25]: Based on the outcomes of the first round of pilot trials (A2.3) we will check the drawbacks for both solutions in order to perform upgrades to the software or hardware that may be deemed necessary in the two solutions. Calibration against known ion concentrations will ensure accuracy and continuous monitoring will facilitate real-time data collection and analysis, allowing for immediate compost management decisions. The system is designed to be user-friendly, displaying clear NPK levels and providing actionable insights through a central dashboard or mobile app. This setup will not only enhance specificity and sensitivity in nutrient measurement but also support adaptability and seamless integration with other sensory technologies, optimising nutrient management and compost quality. **A1.3.4** Final version of the ADSs [M35 – M36]: A final version of the ADS will be built based on the outcomes of the 2nd round of pilot trials (A2.4). The system will be prepared for continued deployment post-project, ensuring all enhancements are integrated and the system is optimised for broader use. **A1.4 Development of Open-Source hardware/software [M13 - M36]:** This activity is focused on developing accessible, scalable open-source software solutions to enable widespread adoption and community-driven improvements of ADS. It will focus on the following sub-activities: **A1.4.1** Data collection during 1st Annual Cycle Testing [M07–M11]: This sub-activity is dedicated to developing a sophisticated rule engine designed to optimise compost fermentation processes, encompassing the specification of critical environmental conditions and thresholds from M07 to M11. These parameters will be encoded into software routines and components using conditional logical rules, forming the backbone of the compost process analytics rule

	engine. Additionally, this phase involves the configuration, deployment, and integration of the tiny data centre for the mixed/edge approach. The tiny data centre will host the rule engine, ensuring efficient data handling and processing close to the data sources, which enhances the system's responsiveness and reduces latency. Comprehensive testing of these systems will validate their efficacy in real-world compost management scenarios, enhancing decision-making and operational controls in compost production. **A1.4.2** Data collection during 2nd Annual Cycle Testing [M13–M24]: For the compost fermentation monitoring solution, the data processing (rules engine) along with datasets for a full composting cycle will be offered as open-source software. **A1.4.3** Release of a Pre-Final compost monitoring solution [M25–M36]**:** Documentation, software and hardware designs, best practices and lessons learned of the integrated compost monitoring approach will be available to the open-source community. **A1.5 Integration of the OpenAgri OS services to the ADS [M09–M36]:** This activity is focused on ensuring that the ADS integrates seamlessly with the OpenAgri Open-Source services, thereby enhancing the functionality and efficiency of the ADS. It will focus on the following sub-activities: **A1.5.1** Testing services within the 1st Annual Cycle Testing [M15–M24]: Review the exact functionalities offered by OpenAgri OS services ("Weather Data Service", "Reporting Service" and "Data Exchange and ACS") through the specification of the respective APIs. Design and provide technical specifications (message sequence diagrams) for the integration of the Compost Monitoring ADS with the selected OpenAgri OS. **A1.5.2** Updates and performance tuning [M10–M12]: Implement the integration specification of A3.1. Optimise the performance of the ADS considering real-time weather data and reporting capabilities. **A1.5.3** Testing services within the 2nd Annual Cycle Testing [M18–M34]: Final integration, testing and validation of the final version of the OpenAgri OS services, as part of the final version of the SIP5 ADS.
Participants involved	Leader: EMBIO; Participants: GSC GR, Farmers Fresh

Milestones

(Related to Activity 1 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	ADS Requirements Document Completed	A1.1	Requirement specification documents	M5
2	Data collection on the first season	1.3.1	Deploy of data collection infrastructure	M11
3	1st version of ADS	1.3.2	Report, code and datasets documenting the operation of the 1st version of ADS	M14
4	2nd version of ADS	1.3.3	Report, with the updated code and datasets documenting the operation of the 2nd version of ADS	M25
5	Final version of ADS	1.3.4	Final report and code documenting Compost monitoring ADS	M36
6	Data collection on the first field trial	A1.4.1	Prototype testing reports, connectivity and functional test results, field datasets availability	M11
7	Data collection on the second field trial	A1.4.2	Data processing (rules engine) along with datasets for a full composting cycle will be offered	M24

8	Release of Open pre-Final Compost Monitoring solution	A1.4.3	Software release notes, version control logs	M36
9	Testing services	A1.5.1	Short report with specifications for integration, code snippets and configuration logs during the 1st Annual Cycle Testing	M24
10	Updates and performance tuning	A1.5.2	Optimization of the performance of the ADS along with weather data	M12
11	Testing services	A1.5.3	Testing and Services during the 2nd Annual Cycle Testing	M34

Activity No. 2	**Start month**	M05	**End month**	M34
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two seasons			
Activity description	This activity is focused on executing extensive field tests to evaluate the effectiveness, usability, and sustainability of the ADS across multiple sites. It aims to conduct comprehensive pilot trials of the developed ADS to validate effectiveness, usability, and sustainability. It will focus on the following sub-activities: **A2.1 Selection of the Testing fields [M05 – M14]:** Select fields for testing the ADS in different environmental conditions. Identify the type and quantity of raw materials to be used for the compost procedure. **A2.2 Design the Testing Phase [M09 – M14]:** Design specific tests to evaluate all features and functions of the ADS. Specify the number of piles and the composting periods (starting date and expected final period). Specify the sampling schedule (once a month) for the BELD analysis. **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** Conduct the piloting and testing activities to perform the dual comparison of the two ADS at the field. Following the project iterative approach, the activities will take place in two annual cycles. The work is split into the following sub-activities. **A2.3.1 1st Annual Cycle Testing [M15 – M21]:** In this phase, the first version of the ADSs that will be created in A1.3.2 will be used. This sub-activity involves rigorous comparative testing of the B.EL.D™ device during the "1st Annual Cycle Testing" phase. By analysing and comparing the NPK measurement results from the B.EL.D™ device with those obtained from other established NPK measuring devices, this sub-activity aims to identify discrepancies and optimise the B.EL.D™ device's accuracy and reliability. The ADSs will be deployed in agricultural fields for the first annual cycle of testing. This testing phase aims to evaluate the performance of the ADSs in detecting and managing the environmental conditions of compost piles and their NPK content, ensuring optimal compost maturity and quality. Data collected during the testing period will be analysed to identify strengths, weaknesses, and areas for improvement. **Based on the collected data,** the project team will compile and complete the first SIP5 performance report. The report will document the findings and outcomes of the first annual cycle of testing, including the performance of the ADSs, challenges encountered, and lessons learned. The report will also outline recommendations for further development and refinement of the ADSs based on the results of the testing phase. **A2.3.2 2nd Annual Cycle Testing [M25 – M33]:** In this phase, the second version of the ADSs that will be created in A1.3.3 based on the findings and recommendations from the first annual cycle of testing, will undergo a second round of similar testing with A2.3 in agricultural fields for the second annual cycle. This testing phase aims to validate improvements made to the ADSs and assess their performance under different operational scenarios. **At the end of this phase,** the project team will compile and complete the final SIP5 performance report. The report will summarise the findings and outcomes of the second annual cycle of testing, including the performance of the ADSs and any additional insights gained.			

Participants involved	Leader: EMBIO; Participants: GSC GR, Farmers Fresh

Milestones
(Related to Activity 2 or Sub Activities)

No.	Milestone	Activity/ Sub Activity	Means of verification	Due date (DD/MM/YYYY)
1	Selection of the testing fields	A2.1	Selection of the fields and identification of the raw materials	M14
	Design the Testing Phase Completed	A2.2	Documented list of fields and designed tests to evaluate the ADSs	M14
2	1st Annual Cycle Testing	A2.3.1	Equipment deployed in the field and start of data collection and the compost monitoring process	M21
3	1st SIP Performance report	A2.3.1	Test reports, performance metrics, and stakeholder feedback	M24
4	2nd Annual Cycle Testing	A2.3.2	Equipment deployed in the field and start of data collection and the compost monitoring process	M33
5	Final SIP Performance report	A2.3.2	Updated test reports, performance improvements documentation	M34

Activity No. 3	Start month	M6	End month	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is focused on spreading awareness and demonstrating the practical benefits of the ADS to ensure its adoption and sustainable use post-project. It will focus on the following sub-activities: **A3.1 Monthly Posts on Social Media [M06 – M36]**: Regular updates and engagement on social media platforms to share progress, insights, and success stories of the SIP5 project, enhancing visibility and fostering community engagement. **A3.2 Organise an Open Day [M24 – M36]:** Plan and execute an Open Day event to showcase the operational ADS to stakeholders, including farmers, advisors, and industry representatives. This will facilitate direct interaction with the technology and feedback collection. **A3.3 Create One Video Testimonial [M30 – M32]:** The SIP partners together with FSH will produce a comprehensive video testimonial documenting the ADS's development, deployment, and benefits, featuring interviews with project participants and showcasing the ADS in action. **A3.4 Participation in Relevant Events [M06 – M36]:** Attend and present at relevant conferences, workshops, and seminars to foster networking, share findings, and learn from others in the field. **A3.5 Community Engagement Workshops for Co-Designing ADS [M06-M36]:** This sub-activity fosters community involvement in ADS development. P2PLab will lead two workshops to train SIP partners on participatory engagement practices and create a working group that includes farmers, farm advisors, and tech startups. The aim is to co-develop community outreach and integration protocols, leading to major co-design kickstart events and successive workshops. These activities aim to develop at least five new community-driven, open-source ADSs that are socially inclusive, responsible, and sustainable.			
Participants involved	Leader: EMBIO; Participants: GSC GR, Farmers Fresh			

Milestones *(Related to Activity 3 or Sub Activities)*				
No.	**Milestone**	**Activity/ Sub Activity**	**Means of verification**	**Due date (DD/MM/YYYY)**
1	Social Media Engagement Established	A3.1	At least 12 posts posted in Linkedin, Facebook and Tweeter/X.	M36
2	Open Day Successfully Hosted	A3.2	Event attendance, participant feedback, event recordings	M36
3	Video Testimonial Produced	A3.3	Video release	M32
4	Successful Participation in Relevant Events	A3.4	Documentation of event participation, attendee feedback, and copies of presented materials	M36
5	Completion of Community Engagement Workshops	A3.5	Workshop attendance logs, workshop training materials, reports on workshop outcomes, documentation of co-developed ADS protocols and designs	M36

4.6.4. Dissemination & Demonstration activities

Dissemination & Demonstration activities				
Activity	**Chanel Type**	**Frequency**	**Targeted audience group**	**Dissemination materials**
Create social media posts and spread them through the partners' accounts and the OpenAgri accounts.	Social Media	Once at least every three months starting on M6.	All	Pictures from the field, stories, other material
One Open Day will be launched in Cyprus to demonstrate the SIP results on the field.	Demonstration Events	Once in the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once in the last year of piloting.	All	A video showcasing the 2 ADS describing their benefits and presenting the results.

4.6.5. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP5	Number of ADSs developed and used in the SIP5	0	2	SIP5 will use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software developed and used in the SIP5	Number of OS Software developed and used in the SIP5	0	1	SIP5 will develop ≥1 OS Software
Actors engaged in the SIP5	Number of actors involved in co-creation and piloting activities	0	10	Open Day will engage real actors in co-creation and piloting

Dissemination				
Organised Open Days	Number of organised Open Days	0	1	SIP5 will host 1 Open Day
Open Day Participants	Number of people participating in the Open Days	0	Y	Open Day will have at least YY participants
Social Media Posts	Number of Social Media posts	0	12	SIP5 will do one post at least every 3 months starting on M6.
Video testimonials	Number of Video testimonials created.	0	1	SIP5 will create 1 video testimonial with the help of WP4 partners.

4.6.6. Evaluation & Comparison metrics

Effectiveness and Performance in Agriculture Scenarios

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 17 - Evaluation metrics for effectiveness and performance in agriculture scenarios for SIP5

No	Metric	Notes
1	**Efficiency/speed of composting**	Monitor and compare the time duration from compost setup to maturation across three distinct processes: traditional composting, edge/mixed based ADS-supported composting, and cloud-based ADS composting. This will help in identifying which approach accelerates the composting process most effectively.
2	**Reduction in manual labour/effort needed**	Assess and compare the decrease in man-hours required for compost monitoring and management tasks across the traditional, edge/mixed ADS, and cloud ADS processes. The focus should be on quantifying the extent to which automation in either ADS configuration reduces the need for manual intervention, thereby streamlining operational efficiency.
3	**Overall production efficiency**	Evaluate and compare the increase in compost production efficiency by examining the input (organic waste) to output (usable compost) ratio before and after the implementation of ADS, distinguishing between traditional processes, edge/mixed version, and cloud version. This comparison will illuminate which system maximises resource utilisation and output quality.

Computing Resource Utilization and Energy Efficiency

The two versions (cloud vs mixed mode) of the ADS will be evaluated against the following metrics:

Table 18 Evaluation metrics for computing resource utilization and energy efficiency for SIP5

No	Metric	Notes
1	**Networking resources** utilisation for data transmission for the two scenarios.	For the cloud-based solution data transmission from multiple LoRaWAN sensors monitoring compost and environmental properties will be evaluated. In the mixed model compost properties data collection and processing will be realised in a local nano-data centre.
2	**Computing resources** utilised for compost sensor readings processing in the two scenarios.	Compost monitoring and decision support on extracting alerts against predefined thresholds, recommendations for compost management actions (stirring, irrigation), and prediction of composting completion. In cloud based the analysis for many compost piles will take place in one server system. In a mixed model the process will be distributed and will be realised in a nano-server system deployed close to the compost piles.
3	**Total energy consumed for data processing and data transmission**	Calculation of consumed energy for monitoring the compost conditions and providing recommendations to the compost manager.
4	**Total energy consumed for completing the farming operation.**	Calculation of consumed energy for completing the composting operation considering manual labour and commuting for visiting the piles.

Comparison Metrics Overview

Table 19 – SIP5 Comparison Metrics

SIP5 Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Efficiency and Speed of Composting	Evaluates how the ADS impacts the time taken from compost setup to maturation.	Reduction in average composting time compared to traditional methods.
Reduction in Manual Labour	Measures the decrease in man-hours required for compost monitoring and management due to ADS automation.	Percentage decrease in manual labour hours.
Overall Production Efficiency	Assesses the input (organic waste) to output (usable compost) ratio improvement.	Increase in compost output per input unit.
Computing & network resources utilisation and energy efficiency		
Networking Resources Utilisation	Measures data transmission volumes and efficiency in both cloud-based and mixed-model scenarios.	Reduction in data transmitted per unit of compost processed.
Computing Resources Utilisation	Evaluates computational load for sensor data processing in cloud versus edge scenarios.	Decrease in processing time and computational resources used.
Total Energy Consumed for Data Processing and Transmission	Calculates the energy used in monitoring, data processing, and transmitting actions.	Reduction in total energy consumption by the ADS system.
Total Energy Consumed for Completing the Farming Operation	Accounts for all energy used in the composting operation including manual and automated processes.	Overall decrease in energy consumption compared to traditional composting methods.
Use of Standards / Interoperability and Switchability		
Evaluation of Data Standards and File Formats	Analysis of data modelling approaches, standardisation mechanisms, barriers, and benefits.	List and short report analysing data modelling and standardisation mechanisms.
Evaluation of Networking/Communication Standards	Analysis of technical specifications of networking/communication standards, including barriers and benefits.	List and short report analysing telecom and IoT communication protocols.
Switchability of Software Modules	Evaluation of the potential to reuse software services in different contexts using containerization technologies.	Report analysing reusability of software modules with containerization technologies (e.g., Docker).
Switchability of Farm Data Collections	Evaluation of the feasibility of retrieving and reusing farm data collections with solutions from different providers.	Report analysing reusability of farm data collections.
Switchability of Hardware Modules	Evaluation of the potential to reuse hardware services in different contexts, focusing on plug and play	Report analysing reusability of hardware modules.

	mechanisms and hardware protocols.	

4.6.7. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**
Technological failure in ADS hardware/software	A1	Regularly update and test hardware/software. Implement redundancy systems. Conduct regular backup procedures.
Integration issues with OpenAgri OS services	A1	Utilise modular design principles to ensure smooth integration. Regular testing with mock services.
Delays in development timelines	A1	Implement agile project management. Regular progress reviews. Adjust resources dynamically as needed.
Low engagement from community or stakeholders	A3	Engage community early and regularly. Employ user-centric design principles. Provide regular updates and incentives for participation.
Data privacy and security breaches	A1	Strengthen security protocols. Regular security audits. Train staff on data handling best practices.
Poor adoption of the developed ADS post-project	A3	Develop comprehensive training and support materials. Establish long-term partnerships with stakeholders. Monitor user feedback post-implementation for continuous improvement.
Weather variability affecting field trial results	A2	Use historical weather data to plan trials. Implement adaptive trial designs. Contingency plans for adverse weather.

5. Conclusion

This deliverable has established a comprehensive foundation for the operationalisation and monitoring of the SIPs within the OpenAgri project. Through detailed SIP Execution Plans, it outlines the deployment areas, piloting schedules, and delineates the responsibilities of all stakeholders involved in each pilot. These plans are crucial to ensure that each SIP is well-prepared to effectively implement the dual ADS models—cloud-based and edge/mixed-based—and to conduct thorough comparative analyses assessing their performance in varied agricultural settings.

Furthermore, a robust evaluation methodology has been established, employing four critical dimensions: Effectiveness and Performance in Agriculture Scenarios, Computing Resource Utilisation and Energy Efficiency, Use of Standards/Interoperability and Switchability, and Regional and Socio-Economic Impacts. This methodology will guide the systematic assessment of each ADS's capabilities, efficiencies, and broader impacts, enhancing understanding of their operational effectiveness and technological efficiency.

The procedures for piloting, reporting, and monitoring have been explicitly defined to facilitate ongoing evaluation and troubleshooting during the pilot phases. The implementation of Monthly and Annual Progress Reports, alongside scheduled SIP meetings, ensures continuous oversight and agile management of the SIPs. These mechanisms are instrumental for identifying and addressing challenges promptly, thereby optimising the pilot outcomes.

As the project progresses, Task T3.3 will build upon the groundwork laid by this document, conducting real-world evaluations of the ADSs developed in each SIP. These evaluations will take place over two growing seasons and will critically assess the efficiency, performance, and usability of the ADSs through the lens of the established metrics. Employing a dual comparison approach, the pilot trials will compare the two co-created ADSs within each SIP, pinpointing the most suitable solutions tailored to specific agricultural and socio-economic contexts.

Ultimately, the insights garnered from these comprehensive evaluations will be synthesised in the annual evaluation reports, providing a transparent and data-driven overview of each ADS's performance. This approach not only aligns with the OpenAgri project's commitment to enhancing the sustainability and efficiency of agricultural practices but also significantly contributes to the strategic decision-making processes concerning the adoption of innovative agricultural technologies.

In summary, this deliverable not only orchestrates an execution strategy for the forthcoming pilot trials but also fortifies the project’s infrastructure, ensuring that each step is geared towards realising the overarching objectives of the OpenAgri initiative. This strategic planning and detailed oversight exemplify a proactive approach to managing complex multi-actor engagements and are indicative of a commitment to achieving a transformative impact on Europe's agricultural sector.

6. ANNEXES

6.1. ANNEX 1 SIP Execution Plan template

SIP Trial Implementation Plan

6.1.1. SIP X [Enter the number of your SIP]

SIP name	SIP coordinator(s) Contact Info
Number of SIP and title/short description	Enter contact details of the coordinator [name, email address]

SIP GENERAL INFORMATION	
SIP sector(s)	*Crop/Livestock?*
Agri-food sector	*(e.g., pre-production, post-harvest etc.)*
Geographical coverage (Country/ Region)	*(Country/ Region)*
SIP Partners	*Enter your SIP Partners.*
Farmers & Advisors involved	*Enter the Farmers & Advisors involved in your SIP*
SIP Challenge (Need/Problem)	*Describe your SIP challenges that the ADS tries to solve.*
ADS Overview	*Brief description of the ADS used in your SIP*
Other Data uses	*Brief description of the other Data uses.*

6.1.2. Participants involved

PARTICIPANTS INVOLVED				
Participant name and type (e.g., SME, RTD etc.)	**Position in the value Chain (e.g., Farmer, Tech. provider, wholesaler etc.)**	**Participant role in the SIP**	**Region / Country**	**Contact person name and e-mail**

6.1.3. Co-created ADS & Data involved in the SIP

ADS Description		
Please provide a description of the ADS you will use in the SIP		
Cloud based ADS Architecture		
Please add a figure presenting the basic (draft) architecture of the Cloud based ADS and a description of the architecture (equipment, components etc.)		
Maturity of the ADS	**Current TRL**	**TRL Goal [M36]**
Edge/Mixed based ADS Architecture		
Please add a figure presenting the basic (draft) architecture of the Edge/Mixed based ADS and add a description of the architecture (equipment, components etc.)		

Maturity of the ADS	Current TRL	TRL Goal [M36]
OpenAgri OS services used		
Please describe which OpenAgri OS services and how will your SIP use them with your Cloud and Edge/ Mixed based ADS(s) based on the descriptions of OS services provided by WP2.		
OS Software & Hardware developed		
Please describe the OS Software & Hardware you will develop and how will your SIP use it with your Cloud and Edge/ Mixed based ADS(s)		

Current state of the ADS	
Devices/ Equipment	*Add the devices you use (Raspberry, UAV, Viewer etc.)*
Operating System	*Describe the operating system and the communication protocols (WiFi, Bluetooth etc.) you use.*
Power Source	*Add the power sources you are using. (Battery, Solar panel etc.)*
Energy Consumption	*How you currently measure the energy consumption?*

DATA TYPES involved in SIP			
Data Category	**Data Items**	**Format**	**Data Standard**
Example: Environmental data	*Temperature (real time, day max, day min, day average), Humidity, Precipitation*	*Numerical data*	*Mention the standard you are currently use, e.g. JSON, csv*
Example: Cultivation related	*Parcel's coordinates, Cultivation type, irrigation system, number of plants per hectare*	*Textual/numerical descriptions*	*Example: "parcel geometries are expressed in GeoJSON format".*
Example: Farmer's activities calendar	*day of planting, day of harvesting, growth (phenological) stages, pesticides applications, performed irrigations, fertilisers*	*csv*	*Example: JSON data object modelling an array of data.*

Other Data Uses	
Purpose:	*Describe the purpose*
Dataset:	*Insert the dataset*
Data Analysis & Processing:	*Add information about data analysis and processing*
Meta-data & use:	*Please add meta-data and use, if need be.*

6.1.4. Activities & Milestones

Activity No. 1	Start month	M3	End month	M13
Activity title	Co-Creation of Cloud and Edge/ Mixed based ADS			
Activity goal	To deploy and operate...			
Activity description	This activity is focused on ..... It will focus on the following sub-activities. **A1.1** Preparation and analysis [M03 – M05]: *Detailed Description* **A1.2** Deployment and operation [M03 – M05]: *Detailed Description* **A1.3** Integration of cloud and Edge/ Mixed based ADS to the OpenAgri OS services **A1.4** *Title of Sub-Activity* [Start Month – End Month]: *Detailed Description*			

Participants involved	Leader: ……..; Participants: ……

Milestones *(Related to Activity 1 or Sub Activities)*				
No.	**Milestone**	**Activity/ Sub Activity**	**Means of verification**	**Due date (DD/MM/YYYY)**

Activity No. 2	**Start month**	M3	**End month**	M36
Activity title	Pilot trials and testing			
Activity goal	To deploy and test the ADS for two seasons...			
Activity description	This activity is focused on ..... It will focus on the following sub-activities. **A2.1** Selection of the Testing fields to test the 2 ADS developed in the SIP [M12 – M14]: *Detailed Description* **A2.2** Design the testing phase for the ADS(s) [M12 – M14]: *Detailed Description* **A2.3** 1st version of ADS(s) (cloud and edge mixed) & 1st Annual Cycle Testing [M15 – M26]: *Detailed Description* **A2.4** Complete the 1st SIP Performance report [M22 – M23]: *Detailed Description* **A2.5** 2nd version of ADS(s) (cloud and edge mixed) & 2nd Annual Cycle Testing [M25 – M34]: *Detailed Description* **A2.6** Complete the Final SIP Performance report [M34 – M35]: *Detailed Description* **A2.7** Final version of ADS(s) (cloud and edge mixed) [M34 – M36]: *Detailed Description*			
Participants involved	Leader: ……..; Participants: ……			

Milestones *(Related to Activity 2 or Sub Activities)*				
No.	**Milestone**	**Activity/ Sub Activity**	**Means of verification**	**Due date (DD/MM/YYYY)**

Activity No. 3	**Start month**	M6	**End month**	M36
Activity title	Dissemination, demonstration and exploitation			
Activity goal	To disseminate and demonstrate the SIP results, aiming to support their exploitation after the end of the project.			
Activity description	This activity is focused on ..... It will focus on the following sub-activities. **A3.1.** Monthly posts on Social media [M06 – M36]: *Detailed Description* **A3.2**. Organise an Open Day [M24 – M36]: *Detailed Description* **A3.3**. Create one video testimonial [Start Month – End Month]: *Detailed Description*			
Participants involved	Leader: ……..; Participants: ……			

Milestones *(Related to Activity 3 or Sub Activities)*				
No.	**Milestone**	**Activity/ Sub Activity**	**Means of verification**	**Due date (DD/MM/YYYY)**

Complete List of SIP Milestones			
No.	**Milestone**	**Related Activity No.**	**Due Date (DD/MM/YYYY)**

6.1.5. Dissemination & Demonstration activities

Dissemination & Demonstration activities				
Activity	**Chanel Type**	**Frequency**	**Targeted audience group**	**Dissemination materials**
Create social media posts and spread them through the partners' accounts and the OpenAgri accounts.	Social Media	Once every month.	All	Pictures from the field, stories, other material
One Open Day will be launched in .... to demonstrate the SIP results on the field.	Demonstration Events	Once at the last year of piloting.	All	Presentation of both ADS in the field to Farmers and Advisors.
Create one video testimonial in collaboration with WP4 to present the 2 ADS, their results and benefits.	Ecosystem Building Events	Once at the last year of piloting.	All	A video showcasing the 2 ADS describing their benfits and presenting the results.

6.1.6. Key Results

Key Performance Indicators				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	Each SIP should use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	Each SIP should develop ≥1 OS Software/Hardware
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	Y	Each Open Days should engage real actors in co-creation and piloting
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	Eash SIP should host 1 Open Day
Open Day Participants	Number of people participating in the Open Days	0	Y	Each Open Days should have at least YY participants
Social Media Posts	Number of Social Media post	0	X	Each SIP should do one post every month.
Video testimonials	Number of Video testimonials created.	0	1	Each SIP should create 1 video testimonial with the help of WP4 partners.

6.1.7. Evaluation metrics

Effectiveness and Performance in Agriculture Scenarios

Computing Resource Utilization and Energy Efficiency

Comparison Metrics Overview

Table 20 – SIPx Comparison Metrics

SIPx Comparison Metrics		
Metric Title	**Metric Description**	**Measurable Outcome**
Effectiveness and Performance of ADS in Agriculture Scenarios		
Computing & network resources utilization and energy efficiency		
Use of Standards / Interoperability and Switchability		

6.1.8. Risk Management

Risks & Mitigation measures		
Description of risk	**Activity concerned**	**Proposed risk-mitigation measures**

6.2. ANNEX 2 SIP Monthly progress Report

SIP (x)- Title

Monthly SIP Progress report *Sustainable Innovation Pilot X: [Please enter here SIP's title]*	
A. SIP Progress Report [Mx]	
Evaluation Summary	***Specific objectives*** SIPx had the following objectives:

	Please provide in a numerical list the objectives 1. . 2. . 3. .
	Key Achievements/Results During this reporting period, the following achievements/results were realised: • Please describe the results.
	Shortcomings/Challenges Where there any obstacles during the operation of SIPx?
SIP Activity Progress	
Activity No. 1 Title	Co-Creation of Cloud and Edge/ Mixed based ADS
Activity Goal	
Activity Progress	*Describe the activities that took part during the reporting period.* **A1.1 Preparation and analysis [M03 – M05]:** **A1.2 Deployment and operation [M03 – M36]:** **A1.2.1** Data collection for cloud and mixed solution for the first round of trials [M05 – M09]: **A1.2.2** 1st version of the Viewer (cloud and mixed) [M09 – M14]: **A1.2.3** 2nd version of Viewer (cloud and mixed) [M22 – M25]: **A1.2.4** Final version of Viewer (cloud and mixed) [M35 – M36]: **A1.3 Development of Open-Source hardware/software [M08 - M36]:** **A1.3.1** Data collection during 1st Annual Cycle Testing [M15 – M21]: **A1.3.2** Data collection during 2nd Annual Cycle Testing [M26 – M34]: **A1.3.3** Release of a Pre-Final Version of the AI models [M34 – M36]: **A1.4 Integration of the OpenAgri OS services to the ADS [M09-M36]:** **A1.4.1** Testing services within the 1st Annual Cycle Testing [M15 – M24]: **A1.4.2** Software Updates [M22 – M25]: **A1.4.3** Testing services within the 2nd Annual Cycle Testing [M26 – M35]:

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					
3					

Activity No. 2 Title	Pilot trials and testing
Activity Goal	
Activity Progress	*Describe the activities that took part during the reporting period.* **A2.1 Selection of the Testing fields to test the 2 Viewer approaches developed in the SIP [M05 – M09]:** **A2.2 Design the testing phase for the Viewer [M09 – M14]:** **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** **A2.3.1** 1st Annual Cycle Testing [M15 – M21]: **A2.3.2** 2nd Annual Cycle Testing [M26 – M33]:

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					
3					

Activity No. 3 Title	Dissemination, demonstration and exploitation
Activity Goal	
Activity Progress	*Describe the activities that took part during the reporting period.*

Activity	Status
Social media posts	
Organise Open Day	
Video testimonial	
Participate in Agriculture related events	
Completion of Community Engagement Workshops	

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					

3					

Deviations-Pilot Corrective actions/ Modifications	*Please provide the **Potential Pilot Modifications** or the **required plans for improvement:***
Next steps	**1) …** **2) …**

B. Key Results				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	Each SIP should use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	Each SIP should develop ≥1 OS Software/Hardware
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	Y	Each Open Days should engage real actors in co-creation and piloting
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	Eash SIP should host 1 Open Day
Open Day Participants	Number of people participating in the Open Days	0	Y	Each Open Days should have at least YY participants
Social Media Posts	Number of Social Media post	0	X	Each SIP should do one post every month.
Video testimonials	Number of Video testimonials created.	0	1	Each SIP should create 1 video testimonial with the help of WP4 partners.

C. Comparison Metrics	
Effectiveness and Performance in Agriculture Scenarios	
Please provide the relevant metrics for SIPx regarding technology accuracy, operational and cost efficiency, time savings and environmental and sustainability impact (e.g. SIP1 speed time needed to complete detection and spraying, minimization of overall environmental footprint etc.)	
Metric No.1: [Title]	
ADS-Cloud solution	**ADS-Edge/Mixed solution**

Metric No.2: [Title]	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Computing and network resources utilization and energy efficiency	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Please elaborate.	Please elaborate.

6.3. ANNEX 3 SIP Annual Evaluation Report

SIP (x)- Title

Annual Evaluation Report ***Sustainable Innovation Pilot X**: [Please enter here SIP's title]*	
SIP Leader	
Country Involved	
Sector	
Partners involved	

A. SIP Progress Report [Mx]	
Evaluation Summary	***Specific objectives*** SIPx had the following objectives: *Please provide in a numerical list the objectives* 1. 2. …
	Key Achievements/Results

	During this reporting period, the following achievements/results were realised: • Please describe the results.
	Shortcomings/Challenges Where there any obstacles during the operation of SIPx?
SIP Plan Progress: *Activities*	
Activity No. 1 Title	Co-Creation of Cloud and Edge/ Mixed based ADS
Activity Goal	
Activity Progress	*Describe the activities that took part during the reporting period.* **A1.1 Preparation and analysis [M03 – M05]:** **A1.2 Deployment and operation [M03 – M36]:** **A1.2.1** Data collection for cloud and mixed solution for the first round of trials [M05 – M09]: **A1.2.2** 1st version of the Viewer (cloud and mixed) [M09 – M14]: **A1.2.3** 2nd version of Viewer (cloud and mixed) [M22 – M25]: **A1.2.4** Final version of Viewer (cloud and mixed) [M35 – M36]: **A1.3 Development of Open Source hardware/software [M08 - M36]:** **A1.3.1** Data collection during 1st Annual Cycle Testing [M15 – M21]: **A1.3.2** Data collection during 2nd Annual Cycle Testing [M26 – M34]: **A1.3.3** Release of a Pre-Final Version of the AI models [M34 – M36]: **A1.4 Integration of the OpenAgri OS services to the ADS [M09-M36]:** **A1.4.1** Testing services within the 1st Annual Cycle Testing [M15 – M24]: **A1.4.2** Software Updates [M22 – M25]: **A1.4.3** Testing services within the 2nd Annual Cycle Testing [M26 – M35]:

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					
3					

Activity No. 2 Title	Pilot trials and testing
Activity Goal	

Activity Progress	*Describe the activities that took part during the reporting period.* **A2.1 Selection of the Testing fields to test the 2 Viewer approaches developed in the SIP [M05 – M09]:** **A2.2 Design the testing phase for the Viewer [M09 – M14]:** **A2.3 Comprehensive ADS Testing and Reporting [M15-M34]:** **A2.3.1** 1st Annual Cycle Testing [M15 – M21]: **A2.3.2** 2nd Annual Cycle Testing [M26 – M33]:

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					
3					

Activity No. 3 Title	Dissemination, demonstration and exploitation
Activity Goal	
Activity Progress	*Describe the activities that took part during the reporting period.*

Activity	Status
Social media posts	
Organise Open Day	
Video testimonial	
Participate in Agriculture related events	
Completion of Community Engagement Workshops	

Milestones

No.	Title	Activity/Sub activity	Means of verification	Due date	Status-Comments
1					
2					
3					

Status of Implementation	**Equipment Used**

	Datasets and Formats
	
	For example:
	
	The gathered data for the pilot:
	
	• *Environmental data, including Temperature (real time, day max, day min, day average), Humidity, Precipitation*
	  ○ *Defined frequency of data collection: Hourly data*
	  ○ *Associated data model/format: JSON, csv*
	• *Farmer's activities calendar*
	  ○ *Defined frequency of data collection: Every couple of days*
	  ○ *Associated data model/format: csv*
	• *Cultivation related*
	  ○ *Defined frequency of data collection: Once*
	  ○ *Associated data model/format: Textual/numerical descriptions*
	• *Earth Observation*
	  ○ *Defined frequency of data collection: Every ~5 days*
	  ○ *Associated data model/format: Geotiff images*

Deviations-Pilot Corrective actions/ Modifications	*Please provide the **Potential Pilot Modifications** or the **required plans for improvement:***
Next steps	**1)…** **2)…**

B. Key Results				
KPI Name	**KPI description**	**Baseline value**	**Target value**	**Comments**
ADSs used in the SIP.	Number of ADSs developed and used in the SIP.	0	2	Each SIP should use 2 ADS (1 cloud and 1 Edge/Mixed based)
OS Software/Hardware developed and used in the SIP.	Number of OS Software/Hardware developed and used in the SIP.	0	1	Each SIP should develop ≥1 OS Software/Hardware
Actors engaged in the SIP	Number of actors involved in co-creation and piloting activities	0	Y	Each Open Days should engage real actors in co-creation and piloting
Dissemination				
Organised Open Days	Number of organised Open Days	0	1	Eash SIP should host 1 Open Day
Open Day Participants	Number of people participating in the Open Days	0	Y	Each Open Days should have at least YY participants
Social Media Posts	Number of Social Media post	0	X	Each SIP should do one post every month.
Video testimonials	Number of Video testimonials created.	0	1	Each SIP should create 1 video testimonial with the help of WP4 partners.

C. Comparison Metrics

Effectiveness and Performance in Agriculture Scenarios	
Please provide the relevant metrics for SIPx regarding technology accuracy, operational and cost efficiency, time savings and environomental and sustainability impact (e.g. SIP1 speed time needed to complete detection and spraying, minimization of overall environmental footprint etc.)	
Metric No.1:	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Metric No.2:	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Computing and network resources utilization and energy efficiency	
Metric No.1: Networking resources utilisation for data transmission for the two scenarios.	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Metric No.2: Computing resources utilised for image processing in the two scenarios.	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Metric No.3: Total energy consumed for data processing and data transmission	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Metric No.4: Total energy consumed for completing the farming operation.	

ADS-Cloud solution		ADS-Edge/Mixed solution	
Use of standards			
Metric No.1: Evaluation of Data Standards and File Formats			
ADS-Cloud solution		**ADS-Edge/Mixed solution**	
Score:		**Score:**	
Metric No.2: Evaluation of Networking/Communication Standards			
ADS-Cloud solution		**ADS-Edge/Mixed solution**	
Score:		**Score:**	
Metric No.3: Switchability of Software Modules			
ADS-Cloud solution		**ADS-Edge/Mixed solution**	
Score:		**Score:**	
Metric No.4: Switchability of Farm Data Collections			
ADS-Cloud solution		**ADS-Edge/Mixed solution**	

Score:		Score:	
Metric No.5: Switchability of Hardware Modules			
ADS-Cloud solution		**ADS-Edge/Mixed solution**	
Score:		**Score:**	

Regional and socio-economic impacts

Choose one of the following answers that best represents you. Please check in the boxes for selection of options.

a) How would you describe your initial expectations for the (Cloud, Edge mixed) ADS?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Exceeded expectations ☐ Met expectations ☐ Below expectations ☐ Far below expectations	☐ Exceeded expectations ☐ Met expectations ☐ Below expectations ☐ Far below expectations

b) How would you rate the ease of use of the (Cloud, Edge mixed) ADS?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Very easy to use ☐ Somewhat easy to use ☐ Neutral ☐ Somewhat difficult to use ☐ Very difficult to use	☐ Very easy to use ☐ Somewhat easy to use ☐ Neutral ☐ Somewhat difficult to use ☐ Very difficult to use

c) How has the complexity or simplicity of the (Cloud, Edge mixed) ADS affected its adoption in your organization?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Significantly influenced adoption rate ☐ Moderately influenced adoption rate ☐ Slightly influenced adoption rate ☐ Not influenced adoption rate	☐ Significantly influenced adoption rate ☐ Moderately influenced adoption rate ☐ Slightly influenced adoption rate ☐ Not influenced adoption rate

d) Would you recommend wider adoption of the (Cloud, Edge mixed) ADS within your organization or sector?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Definitely yes ☐ Probably yes ☐ Not sure ☐ Probably not ☐ Definitely not	☐ Definitely yes ☐ Probably yes ☐ Not sure ☐ Probably not ☐ Definitely not

e) How would you rate the willingness for adopting the (Cloud, Edge mixed) ADS within your organization?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Very high resistance ☐ High resistance ☐ Moderate resistance ☐ Low resistance ☐ No resistance	☐ Very high resistance ☐ High resistance ☐ Moderate resistance ☐ Low resistance ☐ No resistance

f) How would you rate the required level of digital skills for the (Cloud, Edge mixed) ADS?

ADS-Cloud solution	ADS-Edge/Mixed solution
☐ Very high ☐ High ☐ Moderate ☐ Low ☐ Very low	☐ Very high ☐ High ☐ Moderate ☐ Low ☐ Very low
g) Are you comfortable with the amount of data that leave the farm?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
☐ Definitely yes ☐ Probably yes ☐ Not sure ☐ Probably not ☐ Definitely not	☐ Definitely yes ☐ Probably yes ☐ Not sure ☐ Probably not ☐ Definitely not
h) Are there any physical objects or structures in the field interfering with the (Cloud, Edge mixed) ADS or the tasks performed?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
☐ No ☐ Yes	☐ No ☐ Yes
If yes please describe:	If yes please describe:
i) How compatible is the (Cloud, Edge mixed) ADS with existing machinery and technology infrastructure in your operations?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
☐ Highly compatible ☐ Mostly compatible ☐ Moderately compatible ☐ Barely compatible ☐ Not compatible	☐ Highly compatible ☐ Mostly compatible ☐ Moderately compatible ☐ Barely compatible ☐ Not compatible
j) How has the (Cloud, Edge/Mixed) ADS contributed to economic growth within your region?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
☐ Significantly contributed ☐ Moderately contributed ☐ Slightly contributed ☐ Not contributed	☐ Significantly contributed ☐ Moderately contributed ☐ Slightly contributed ☐ Not contributed
k) How has the utilization of (Cloud, Edge/Mixed) ADS addressed the digital gap in your region?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
☐ Greatly reduced the digital gap ☐ Somewhat reduced the digital gap ☐ No significant impact on the digital gap ☐ Worsened the digital gap	☐ Greatly reduced the digital gap ☐ Somewhat reduced the digital gap ☐ No significant impact on the digital gap ☐ Worsened the digital gap
l) Which ADS would you choose and why? What makes it the best fit for you?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**
Answer:	Answer:
m) What are your overall thoughts on the (Cloud, Edge/Mixed) ADS?	
ADS-Cloud solution	**ADS-Edge/Mixed solution**

Answer:	Answer:

End of Deliverable 3.1

‘Pilot Plan & Evaluation Methodology’