



Deliverable D5.2 DEPLOYMENT & EVALUATION REPORT, V1

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Acronyms and Abbreviations

Acronyms and Abbreviations	
AGINS	AgroInsurance International
AI	Artificial Intelligence
ATB	Institut für angewandte Systemtechnik Bremen GmbH
AUTH	Aristotle University of Thessaloniki
CA	Consortium Agreement
DES	Deimos Spain
DME	DEIMOS ENGENHARIA SA
DMK	DMK Deutsches Milchkontor GmbH
EC	European Commission
EEAB	External Expert Advisory Board
EGM	Easy Global Market SAS
EO	Earth Observation
EURAC	Accademia Europea di Bolzano (Eurac Research)
EV ILVO	Eigen Vermogen van het Instituut voor Landbouw en Visserij Onderzoek
ExBo	Executive Board
FEU	Farm Europe
ICCS	Institute of Communication and Computer Systems
GA	General Assembly
GDPR	General Data Protection Regulation
HE	Homomorphic Encryption
HPC	High Performance Computing
IFAPA	Instituto Andaluz de Investigación y Formación Agraria, Pesquera y Alimentaria
IPR	Intellectual Property Rights
KUVA	Kuva Space Oy
LUKE	Natural Resources Institute Finland
MIGAL	MIGAL Galilee Research Institute
ML	Machine Learning
MPC	Multi-Party Computation
MST	Management Support Team
NP	Neuropublic SA
OHB DS	OHB Digital Services GmbH, Bremen, Germany
PET	Privacy Enhancing Technologies

PO	Project Officer
PSNC	Instytut Chemii Bioorganicznej Polskiej Akademii Nauk
R&D	Research and Development
RIL	Research and Innovation Lab
SME	Small and Mid-size Enterprise
UGent	Universiteit Gent
VITO	Vlaamse Instelling voor Technologische Onderzoek
VRI IES	Foundation "Institute for Environmental Solutions"
VTT	Technical Research Centre of Finland Ltd.
WODR	Wielkopolski Ośrodek Doradztwa Rolniczego w Poznaniu
WP	Work Package

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1 Introduction

1.1 Project overview

ScaleAgData is a response to the call HORIZON-CL6-2022-GOVERNANCE-01-11 Upscaling (real-time) sensor data for EU-wide monitoring of production and agri-environmental conditions. The ScaleAgData project will run from January 2023 till December 2026 and consists of a consortium of twenty-six partners from fourteen countries. The vision of ScaleAgData is two-fold. On one hand it wants to obtain insights in how the complex data streams should be governed and organised (governance call). On the other hand, it aims to develop the data technology needed to scale data collected at the farm level to regional datasets, agri-environmental monitoring and the management of agricultural production.

To do so, ScaleAgData has five objectives:

- Developing innovative approaches for collecting in-situ data and applying data technologies.
- Enabling and promoting data sharing along the entire data value chain.
- Demonstrating how the sensor data can be scaled to agri-environmental data products at the national, regional or European level.
- Demonstrating the benefit of the improved monitoring capacities in a precision farming context.
- Demonstrating the benefit of upscaled regional datasets for the agricultural sector in general.

During its lifecycle, the project will explore seven innovation areas: innovative sensor technology, edge processing, data sharing architecture and data governance, satellite data augmentation, from data assimilation to service development, privacy-preserving technology, and data integration methodologies.

Six Research and Innovation Labs (RIL) have been identified within the project, across various biogeographical regions of Europe, where different data upscaling and integration models or approaches will be evaluated and demonstrated. The six RILs are: water productivity, crop management, yield monitoring, soil health, grasslands and sustain dairy. Recommendations will be formulated on how such integrated datasets can be capitalized to help national and regional policy making to strengthen both the competitiveness and sustainability of European agriculture.

1.2 Scope of the document

This deliverable, D5.2, documents the integration, deployment, and evaluation of demonstrators within the ScaleAgData project, focusing on how validated methodological frameworks and prototypes are implemented in real-world settings. It is the result of efforts in Task 5.2 (Integration, Deployment, and Setup of Demonstrators) and Task 5.3 (Coordination, Monitoring, Evaluation & Impact Analysis), which collectively ensure the seamless operation, testing, and assessment of the project's innovations.

Task 5.2 outlines the deployment of demonstrators within Research and Innovation Labs (RILs), focusing mainly on existing end-user applications that are enhanced with ScaleAgData services. Each RIL

Leader coordinates and documents the integration process, ensuring alignment with project objectives. The demonstrators serve as practical tools for end-users, supporting real-world validation and use-case testing.

Task 5.3 focuses on demonstration, evaluation, and impact assessment of the deployed solutions. The performance of the demonstrators is analyzed based on predefined Key Performance Indicators (KPIs), tracking the execution, effectiveness, and scalability of the applications. Lessons learned from this process are fed back into the project's co-design and development phases (WP2, WP3, WP4), enabling continuous improvement. Evaluation methodologies, including structured reporting templates and cross-WP collaboration, help identify potential challenges and ensure optimization of the demonstrators' performance. Additionally, feedback and insights gathered through Task 5.3 are continuously integrated into Task 5.2, ensuring that demonstrator integration benefits from real-world performance analysis and user feedback, leading to iterative improvements and enhanced alignment with end-user needs.

This deliverable provides insights into the progress made in integrating ScaleAgData solutions into operational environments, highlights key findings from the evaluation process, and presents recommendations for further refinement in subsequent project phases.

1.3 Document structure

This document is structured as follows:

- **Section 1 - Introduction:** Provides an overview of the project, the scope of the document, and its structure.
- **Section 2 - Methodology:** Describes the demonstrator development process, including preparation, execution, and evaluation, as well as the methodology for evaluating objectives, impact, and wider impact.
- **Section 3 - Overview of RIL Demonstrators:** Presents the RIL demonstrators, including a general description, a summary table, and detailed reports on each demonstrator.
- **Section 4 - Conclusion:** Summarizes key findings and final remarks.

This structure ensures a clear presentation of the demonstrator development process, evaluation methodology, and results from the first iteration of the project.

2 Methodology

2.1 Overview of Demonstrator Development Process:

The development of the demonstrators within the ScaleAgData project follows a structured, multi-phase approach to ensure effective integration, deployment, and evaluation across the Research and Innovation Labs (RILs).

The process consists of three main stages: **Preparation, Execution, and Evaluation**, each comprising specific tasks and milestones. A list of indicative actions for each stage is included below.

2.1.1 Demo Preparation

This phase focuses on the initial planning, design, and setup of the demonstrators. Key activities include:

- **Defining the demonstrators** by detailing their objectives, functionalities, and expected outcomes.
- **Establishing a timeline** to structure deployment and iteration cycles.
- **Collaborating with technology providers** to ensure the integration of necessary sensor technologies, EO data sources, and analytical tools.
- **Identifying required data sources and system components** for demonstrator functionality.
- **Engaging stakeholders** to ensure participation from farmers, agronomists, policymakers, and other relevant actors.
- **Preparing technical and operational resources**, including documentation, training materials, and technical components.
- **Conducting internal testing and validation** before deployment to ensure system reliability.

2.1.2 Demo Execution

During this phase, the demonstrators are deployed in the RILs, engaging end-users in real-world agricultural settings. Key activities include:

- **Executing the demonstration** according to the predefined plan.
- **Monitoring and troubleshooting** any technical or operational issues during the demo period.
- **Engaging with participants** to collect insights and ensure usability of the solutions.
- **Capturing data and user feedback** to assess demonstrator effectiveness and identify areas for improvement.

2.1.3 Demo Evaluation

The final phase focuses on assessing the impact and effectiveness of the demonstrators. Key activities include:

- **Reporting on progress**, documenting performance results and initial findings.
- **Identifying and defining key evaluation aspects** based on project objectives and stakeholder needs.
- **Selecting and applying evaluation methodologies** aligned with the guidelines from D5.1, D5.3, including KPIs established in T5.1.
- **Utilizing collaborative tools and designing report templates** for systematic data collection.
- **Expanding, refining, and updating the initial KPIs** from Deliverable 5.3 through workshops to align with Lab-specific impacts, with final KPIs presented in Deliverable 5.2..

- **Evaluating the Demonstrators' impact and assessing how different target groups benefit** from the developed solutions.
- **Feeding evaluation results into WP2 and providing recommendations** to support ongoing development and refinement in the next iteration.

This iterative development process ensures that the demonstrators evolve based on real-world feedback, increasing their relevance, usability, and impact across European agricultural systems.

2.2 Evaluation Methodology

The evaluation framework is thoroughly designed to assess the project's effectiveness in achieving its defined objectives, anticipated impacts, and broader contributions to sustainability and policy goals. The methodology aligns with the guidelines established in D5.1 and focuses on three primary areas: Objectives, Impact, and Wider Impact (see section 2.2.1; 2.2.2; 2.2.3). Each RIL will specify KPIs linked to their thematic focus, ensuring a nuanced and relevant evaluation process.

ScaleAgData aims to support sustainability and competitiveness within Cluster 6 – Food, Bioeconomy, Natural Resources, Agriculture, and Environment, aligning with key EU policies such as the European Green Deal, Farm to Fork Strategy, and European Climate Pact. By developing data-driven technologies, the project seeks to enhance smart farming, improve agri-environmental monitoring, and advance sustainability initiatives, potentially contributing to Common Agricultural Policy (CAP) eco-schemes and more informed decision-making in agriculture. These efforts can directly support progress toward SDGs 2, 6, and 12, promoting more sustainable agriculture, efficient resource use, and environmental protection, while also potentially contributing indirectly to farming communities and public health (SDGs 1 and 3). Through this targeted approach, ScaleAgData has the potential to strengthen EU sustainability objectives and contribute to global SDG commitments.

Building on its alignment with the European Green Deal, SDGs, and broader EU policy objectives, ScaleAgData has developed additional KPIs through targeted workshops to better capture the specific impacts of each Research and Innovation Lab (RIL). These KPIs provide a more precise assessment of how the developed solutions contribute to sustainability and policy goals. The full list of RIL-specific KPIs is detailed in section 3.3, RIL Demonstrator Reports, under the Evaluation and Impact section.

This structured evaluation approach ensures that ScaleAgData remains aligned with both internal project goals and external sustainability benchmarks. By systematically assessing each **RIL's contributions**, the evaluation framework fosters **continuous improvement**, reinforcing the project's alignment with the **European Green Deal, SDGs, and broader EU policy objectives**

2.2.1 Evaluation of Objectives

Each project objective is associated with specific KPIs to measure its achievement:

- **Objective 1:** Developing innovative approaches for collecting in-situ data and applying data technologies by actively involving stakeholders in the agricultural production process.
 - KPI.O1: Implementation of sensor and sampling innovations.
 - KPI.O2: Applicability of sensors: Investigation of field-based sensors in different agricultural zones or agri-environmental systems and exploration of hyperspectral sensor payloads suitable for drone observation.

- KPI.O3: Data processing architecture: Testing and application of edge analytics and federated learning technology in processing platforms.
- **Objective 2:** Enabling and promoting data sharing along the entire data value chain.
 - KPI.O4: Adoption and demonstration of data sharing best practices by RILs, ensuring sensor data is readily available according to established metadata and governance models.
 - KPI.O5: Development of a best practice document detailing various governance models, highlighting drawbacks and benefits for different stakeholders.
 - KPI.O6: Organization of workshops to emphasize the importance of data sharing.
- **Objective 3:** Demonstrating how readily-accessible, locally-collected sensor data can be scaled to agri-environmental data products at national, regional, or European levels.
 - KPI.O7: Development of improved or new data products that provide information on agri-environmental conditions, accessible to various stakeholders within and beyond the RI labs, covering different environmental axes (water, air, soil, and living organisms).
- **Objective 4:** Demonstrating the benefit of improved monitoring capacities of agri-environmental conditions in a precision farming context.
 - KPI.O8: Utilization of improved data products by RILs to optimize services to farmers, offering information or services not feasible with in-situ sensors alone.
 - KPI.O9: Application of improved data products in precision farming contexts outside of the RILs, benefiting farmers without access to sensor technology.
- **Objective 5:** Demonstrating the benefit of upscaled regional datasets for the agricultural sector in general.
 - KPI.O10: Evaluation of improved data products by various users (both within and outside the consortium) regarding their relevance and usability.
 - KPI.O11: Number and feedback from the project's co-engagement activities, such as workshops and webinars with national or EU policymakers, or collaborations with other projects or initiatives like the "Partnership of Agriculture of Data."

More information on the Objectives of the project and the corresponding KPIs is included in the Grant Agreement (Part B - Section 1.1.2).

2.2.2 Evaluation of Impact

The impact assessment focuses on the project's contributions to strengthening capacities in smart farming and agri-environmental monitoring, aligned with specific topic outcomes:

- **Topic Outcome 1:** Strengthening capacities for smart farming to enhance the environmental and economic performance of the agricultural sector.
 - KPI.I1: Number of newly developed Smart Farming solutions.
 - KPI.I2: Number of regions where these solutions were tested.
 - KPI.I3: Number of engaged potential users for all Smart Farming-related data products.

- **Topic Outcome 2:** Strengthening capacities for agri-environmental (climate) monitoring, particularly of soil and crop conditions.
 - KPI.I4: Number of agri-environmental soil and crop parameters covered.
 - KPI.I5: Number of regions where these solutions were tested.
 - KPI.I6: Number of engaged potential users for each soil and crop-related data product.
- **Topic Outcome 3:** Providing inputs to the work of the Horizon Europe candidate partnership “Agriculture of Data” and the potential Research & Innovation mission on soil health.
 - KPI.I7: Number of project agriculture data products of interest to the “Agriculture of Data” partnership.
 - KPI.I8: Number of developed services and data relevant to the Research & Innovation mission on soil health.

More information on the impact assessment of the project and the relevant KPIs is included in the Grant Agreement (Part B, Section 2.1.1).

2.2.3 Evaluation of Wider Impact

Beyond direct objectives, the evaluation encompasses the project's broader contributions to innovative governance models, environmental observation, and alignment with European policies and Sustainable Development Goals (SDGs):

- **Wider Impact 1:** Innovative governance models enabling sustainability and resilience, leading to better-informed decision-making processes and societal engagement.
 - KPI.I9: Number of defined governance and business models.
 - KPI.I10: Number of stakeholders involved in defining these models.
- **Wider Impact 2:** Advancement in Green Deal-related domains through the deployment and exploitation of Environmental Observation data and products.
 - KPI.I11: Number of Green Deal objectives and actions contributed to.

The demonstrators' impact will be assessed in relation to their contribution to Smart Farming and Agri-Environmental Monitoring, particularly in supporting EU Green Deal objectives. According to the European Commission, the EU's goals include ensuring food security amidst climate change and biodiversity loss, reducing the environmental and climate footprint of the EU food system, strengthening the EU food system's resilience, and leading a global transition towards competitive sustainability from farm to fork.
- **Wider Impact 3:** Strengthening the Global Earth Observation System of Systems (GEOSS).
 - KPI.I12: Number of project-specific data collections available in NextGEOSS.
 - KPI.I13: Number of engaged GEO activities testing or providing feedback on project outputs.
- **Wider Impact 4:** Enhancing sustainability performance and competitiveness in domains covered by Cluster 6 through the deployment of digital and data technologies.
 - KPI.I14: Number of Cluster 6 areas of intervention contributed to.
 - KPI.I15: Number of Cluster 6-related policies and strategies influenced.

The demonstrators of ScaleAgData support sustainability and competitiveness in the following Cluster 6 areas: Environmental observation, Agriculture, forestry, rural areas, Food systems, Soil

health & food, and European partnerships. Also they contribute to the following European Policies: European Green Deal, Farm to Fork Strategy, and European Climate Pact.

- **Wider Impact 5:** Informing and engaging stakeholders and end-users, including primary producers and consumers, through effective platforms such as Agricultural Knowledge and Innovation Systems (AKIS).
 - KPI.I16: Number of engaged users.
 - KPI.I17: Number of co-design workshops.
 - KPI.I18: Number of capacity building webinars and workshops.
- **Wider Impact 5:** Strengthening EU and international science-policy interfaces to achieve the Sustainable Development Goals (SDGs).
 - KPI.I19: Number of SDG indicators the project is directly contributing to.
 - KPI.I20: Number of SDG targets the project is indirectly contributing to.

The demonstrators of the project contribute directly to the following SDGs:

- SDG 2 (End Hunger): Monitoring agricultural production per labor unit and the agricultural area under sustainable agriculture.
- SDG 6 (Clean Water and Sanitation): Monitoring changes in water-use efficiency.
- SDG 12 (Responsible Consumption and Production): Supporting policy development for sustainable consumption and tracking material footprint and resource efficiency.

Also, they have an indirect link to the following SDGs:

- SDG 1 (No Poverty): Increasing agricultural productivity to reduce poverty in farming communities.
- SDG 3 (Good Health and Well-being): Reducing hazardous pollutants through better environmental monitoring.

More information on the wider impact of the project and the relevant KPIs is included in the Grant Agreement (Part B, Section 2.1.2).

2.2.4 Steps for Impact Evaluation

Tailoring methodology

The significant elements of our tailored evaluation methodology are as follows:

- **Dual-Level Approach:**
 - **Macroscale Evaluation:** Assess societal, economic, technological, and environmental impacts of the developed products and services.
 - **Microscale Evaluation:** Gauge solutions added value among specific focus groups.
- **Performance Analysis:**
 - Monitor demonstrator performance using defined KPIs, timelines, progress reports, and regular RIL meetings.
 - Quickly identify and address potential shortcomings and delays.
- **Impact Assessment:**

- Has as a starting point the KPIs established in Task 5.1, using standardized reporting templates.
- Refine and enrich the initial KPIs (from D5.1, D5.3) through workshops and stakeholder input, with the final KPI list presented in D5.2 and D5.4
- **Targeted Evaluation:**
 - Focus on specific target groups to tailor data collection and indicator selection, ensuring the evaluation is relevant to key beneficiaries.
- **Evaluation Tools & Methods:**
 - Employ collaborative tools such as surveys, KPI templates, and questionnaires to gather user feedback.
 - Use both qualitative and quantitative methods to ensure a broad user base (quantitative) and in-depth engagement (qualitative).
- **Transparency & Standardization:**
 - Utilizes a systematic and standardized evaluation process that supports continuous monitoring and iterative improvements.

Facilitation Workshop

As part of the ScaleAgData annual project meetings, we organized a workshop on November 19, 2024, to explore the potential impact of developed data products and services and provide a more precise assessment of their contributions to policy goals and sustainability. Facilitated by T. Coppens (ILVO), the workshop focused on identifying key impact areas, examining their dimensions, determining indicators, and mapping the impact on relevant target groups to understand how the developed solutions can create value for them. This effort served as an initial brainstorming step to lay the groundwork for a more comprehensive evaluation of the project's broader impact.

Workshop Process:

- **Introduction:** We began our workshop with a presentation that provided the necessary information about the workshop's descriptions, concepts, objections and methodology to ensure a common understanding and clarity of the process.
- **Defining Impact Areas** – Identifying main aspects where the developed data products and services could create an impact (e.g., for economic impact: cost reduction, efficiency gains, or revenue generation) for each impact category (e.g., economic, environmental, technological, or societal impact).
- **Identifying Measurable Indicators** –determining specific metrics—both quantitative and qualitative—to evaluate and track these impacts (e.g., percentage of cost savings, reduction in processing time, or improvement in data quality), ensuring a clear framework for assessing the effectiveness of each proposed solution.
- **Linking to Target Groups:** Indicators were mapped to relevant user groups.
- **Prioritization:** Participants voted to determine the most significant indicators for each R&I Labs

The interactive, structured approach ensured a clear framework for assessing the impact of data-driven solutions within the project.

Analysis of the workshop results and Consultation

After the workshop, all collected inputs were digitized and structured for further analysis. To ensure clarity and refinement, an organized online workshop was conducted, where participants reviewed

and discussed the results. This session allowed for validation, clarification of key points, and further refinement of the identified impact areas and indicators, ensuring alignment with project objectives.

Refine and enrich Impact Indicators

We enriched, refined and structured the co-developed indicators to align with the HE indicator framework while preserving their original content and logic. A selection of indicators was made to ensure a clearer representation of the impact of ScaleAgData data product and services, enabling a more effective, direct, and streamlined evaluation process.

Development of Template for impact Indicators

Data Collection Approach:

Due to the limitations outlined in Section 2.2.5, establishing reference values for some indicators proved challenging, and comparative values may not yet be available for certain cases. To address this, we adopted a hybrid approach, incorporating both quantitative and qualitative values. This included baseline and target values for each KPI, along with estimated values where reference data was unavailable. To determine estimated values R&I Lab partners were asked to evaluate the potential contribution of ScaleAgData data products and services to each indicator based on their expertise and experience. This approach facilitated the collection of meaningful insights while minimizing administrative burden and avoiding limitations on input.

To streamline the process, we developed a structured template (Table 1) for value collection, which:

- Provides a clear description of each KPI.
- Links relevant data products and services.
- Aligns with the co-developed impact dimensions.
- Links to target Groups
- Defines baseline values and measurement units clearly.
- Offers multiple options for selecting data sources and measurement methods, including:
 - Historical data from use cases compared to baseline values.
 - Generic historical data compared to standard baseline values.
 - Expert judgments via surveys or interviews.

Figure 1:: Template for gathering Indicator values

KPI Description:			
Link to the Data Product and Services:			
Link to the Impact Dimension(Economic/social/Scientific):			
Target Group/s :			
Data sources/ and measurement methods			
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>			
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) Estimated value (Assuming <u>ScaleAgData</u> data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) <u>ScaleAgData</u> data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)
			Comments Please shortly explain the reason of your choice.

Evaluation Strategy:

For products and services that had already undergone testing, and in the improvement process, the assessment was conducted based on their observed performance outcomes, ensuring that the evaluation reflected real-world functionality and effectiveness. For products and services that had not yet reached implementation and testing, the evaluation was based on their expected result and estimated contributions, assessing their potential impact once fully deployed and operational.

Figure 2: Impact assessment approach

Measurement units/ Estimated Value		Measurement units/ Estimated Value	
Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) Estimated value (Assuming <u>ScaleAgData</u> data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, <u>ScaleAgData</u> data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) Estimated value Based on your knowledge and experience (considering current result of the products), <u>ScaleAgData</u> data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.

Outcome Interpretation:

- The reliance on estimated values in the early evaluation phase can lead to an optimistic outlook for certain indicators.
- As the evaluation transitioned to actual product results, some indicators can reflect lower values compared to initial estimates due to the consideration of real accuracy levels.

This methodology ensured a structured yet flexible assessment process, adapting to the maturity level of the products while providing valuable insights into their potential impact.

2.2.5 Limitations and Challenges of the Impact Assessment

Below is a summary of the key challenges encountered during the impact evaluation process:

- **Defining baseline values:** Establishing baseline values for impact assessment requires integrating multiple sources, such as proprietary data, published literature, statistical records, and expert insights. However, discrepancies between these sources can complicate the process.
- **Lack of historical data:** In some cases, no relevant historical data is available, making it impossible to establish past benchmarks for comparison.
- **Data accessibility issues:** Some required data is difficult to obtain, as it must be sourced from multiple stakeholders, including farmers and suppliers of agricultural pesticides and herbicides. Inconsistent data-sharing practices further complicate access.
- **Limited time for data collection:** The time required to collect relevant data frequently enough for comparison with baseline values is often insufficient.
- **Challenges in measuring long-term impact:** Even when comparative data is collected regularly:
 - The intended impacts may not be measurable within the short duration of the project.
 - Certain indicators (e.g., reductions in working time, travel costs, and travel time) may not fully capture the benefits of ScaleAgData products and services. End users must go beyond initial testing and actively integrate ScaleAgData into their daily operations for its true impact to be reflected.

2.2.6 Co-Design Aligned Evaluation: Assessing Value, Usability, and Usefulness

The integration of Needs Assessment and Solution Evaluation is a fundamental aspect of our adapted approach, as emphasized in the PMI Business Analysis Guide(please see D5.3 for more information). By actively collaborating with WP2 in co-design activities, we ensure that the evaluation process remains effective, stakeholder-driven, and aligned with the project's objectives. Key outputs from the co-design process—such as business, stakeholder, functional, and non-functional requirements, acceptance criteria, and estimated timeframes—are incorporated into the execution plan to facilitate continuous monitoring. This enables timely adjustments and ensures better alignment with evolving project needs.

To evaluate the added value, usability, and usefulness of the products, we utilized acceptance criteria, stakeholder and business requirements, as well as insights gathered from RI Lab evaluation workshops. These were formulated into structured questions used during demonstrations to support a

comprehensive assessment, then integrated into Mentimeter or surveys, enabling systematic data collection and analysis. This structured approach ensured that stakeholder input was effectively captured, fostering iterative improvements to the products. The prepared questions used for evaluation are presented in ANNEX 3.

3 Overview of RIL Demonstrators

3.1 General Description

The Research and Innovation Labs (RILs) in ScaleAgData serve as testing and validation environments for the integration of sensor data, Earth Observation (EO) products, and advanced digital tools in real-world agricultural settings. Each RIL is designed to explore different thematic areas, addressing key challenges in smart farming, precision agriculture, and sustainability monitoring. The six RILs represent diverse agricultural landscapes, covering a variety of biogeographical zones, crop types, and sensor technologies, ensuring scalability and transferability of solutions across Europe.

The primary objectives of the RIL demonstrators are:

- Integrating and upscaling agricultural data from multiple sources to improve decision-support tools.
- Deploying and validating digital farming solutions that enhance productivity, sustainability, and policy monitoring.
- Ensuring cross-sector collaboration by involving farmers, agronomists, policymakers, and technology providers in real-world testing environments.
- Assessing the impact of digital solutions through structured evaluation methodologies, ensuring adoption and scalability across Europe.

Each RIL focuses on a specific application domain, ranging from crop management and soil health monitoring to yield prediction and grassland management. The RILs also differ in their level of technological maturity, with some operating in well-established smart farming ecosystems, while others explore emerging technologies and experimental data integration models.

A key feature of the RIL approach is the inclusion of sub-RILs in selected regions, allowing for:

- Comparative analysis of different agro-ecological conditions to improve transferability.
- Testing and refining digital solutions in various farming systems and climates.
- Enhanced decision-making regarding the usability of products and services across multiple agricultural settings.

3.2 Summary Table of RIL Demonstrators

The table below summarizes the six RILs, highlighting their **thematic focus, key technologies, and demonstrator objectives**:

Table 1: Demonstrators of RILs during the first iteration of the project.

RIL Thematic Focus	Title of Demonstrators	Key Technologies
RIL1 Water Productivity	Field water status assessment for target crop	IoT sensor data & EO data products
RIL 2 Crop Management	Policy Monitoring Tool	IoT sensor networks, EO Data, GIS platforms, data aggregation and fusion
	Sustainability monitoring - grano.net®	In situ weather data, soil data, farm log, EO data
	Crop Management	Weather data, Observational data, dictionary data, NDVI data

RIL 3 Yield Monitoring	Improved potato tare estimator	Imaging and Vision Systems, weight sensors, moisture sensors, EO data, data aggregation and fusion & Machine Learning and image recognition software
	Potato and winter wheat yield estimation	Yield sensors on harvesters, Machinery data, Digital Twin model, Machine learning & Few shot learning
RIL 4 Soil Health	Use of Federated Learning for topsoil Soil Organic Carbon (SOC) model building at regional and national level	Copernicus EO, RI Environment, Flower AI framework, QGIS & cloud computing technologies
RIL 5 Grasslands	Mediterranean grasslands productivity in a changing environment	EO data, in situ data, ML & collaborations
	Monitoring the productivity of mountain grasslands	EO data, in situ data, ML & collaborations
RIL 6 Dairy	Milk quality forecasting	in-situ data, meteorological data, time series forecasting models

Each demonstrator within the RIL network is designed to test, validate, and refine digital agricultural technologies, ensuring their scalability and impact across European farming systems. The insights gained from these demonstrators will contribute to the broader ScaleAgData framework, supporting data-driven decision-making for both farmers and policymakers.

3.3 RIL Demonstrator Reports

For each of the six RILs, include a section with the following information:

3.3.1 RIL1 – Field water status assessment for target crop

3.3.1.1 Demonstrator Overview

Thematic focus: field water or soil moisture status assessment using different sensor data.

Main Objective: Testing and demonstration of field water status assessment using different sensor data to support irrigation decision making

3.3.1.2 General Description

The demonstrator aims to test and demonstrate the assessment of field water status using different sensor data to support irrigation decision making. Local soil moisture measurements are the most direct approach to access field soil moisture status. However, if soil moisture sensors are not available

in all fields of interest evapotranspiration-based approach where soil water deficit is calculated from meteorological station data might be the next option. In both cases, soil moisture and evapotranspiration maps could be obtained as EO data products, thus providing further potential for upscaling of models for field water status assessment. In this demonstrator we tested and compared soil water status assessment from IoT sensor data and EO data products.

3.3.1.3 Technologies Used

IoT sensor data:

- Soil probe data (soil moisture)
- Meteorological station data (evapotranspiration data product, precipitation)

EO data products provided by DHI group:

- Soil moisture
- Evapotranspiration

3.3.1.4 Deployment Information - Timeline

Currently, it was demonstrated on acquired data from cropping season 2024 and will be further tested in a near-real time regime during cropping season 2025 in pilot sites in Latvia and Israel.

3.3.1.5 Integration with Existing Systems

In Latvia, irrigation isn't widely practiced especially in large open fields. Involved farming company has used different irrigation techniques for growing medical and aromatic plants which are sensitive to drought caused stress. However, decision making on irrigation planning has been based on subjective onsite observations and manually implemented. Therefore, any introduction of sensor data based decision making could be considered as a local innovation.

In Israel, irrigation is an imperative and existential practice in agricultural activities due to the geographical-climatic conditions of the Middle East. Despite the advanced and smart irrigation technologies applied to every aspect of agriculture in Israel, climate change requires the adoption of target crops that are particularly efficient in both their water consumption and their nutritional values.

During these pilot studies different options for assessment of fields water status are tested as well as result delivery and representation to the farmer.

The main challenges are related to different sensors used for monitoring of soil moisture as well as different soil types, thus requiring specification of unique thresholds for different soil and crop types.

3.3.1.6 Deployment Locations

The demonstration has been performed in two distant regions:

- Vidzeme region in Latvia where irrigation is tested in peppermint (*Mentha x piperita*) fields (4 ha)
- Hula Valley in North Israel where irrigation is tested in quinoa (*Chenopodium quinoa*) fields (3,6 ha)

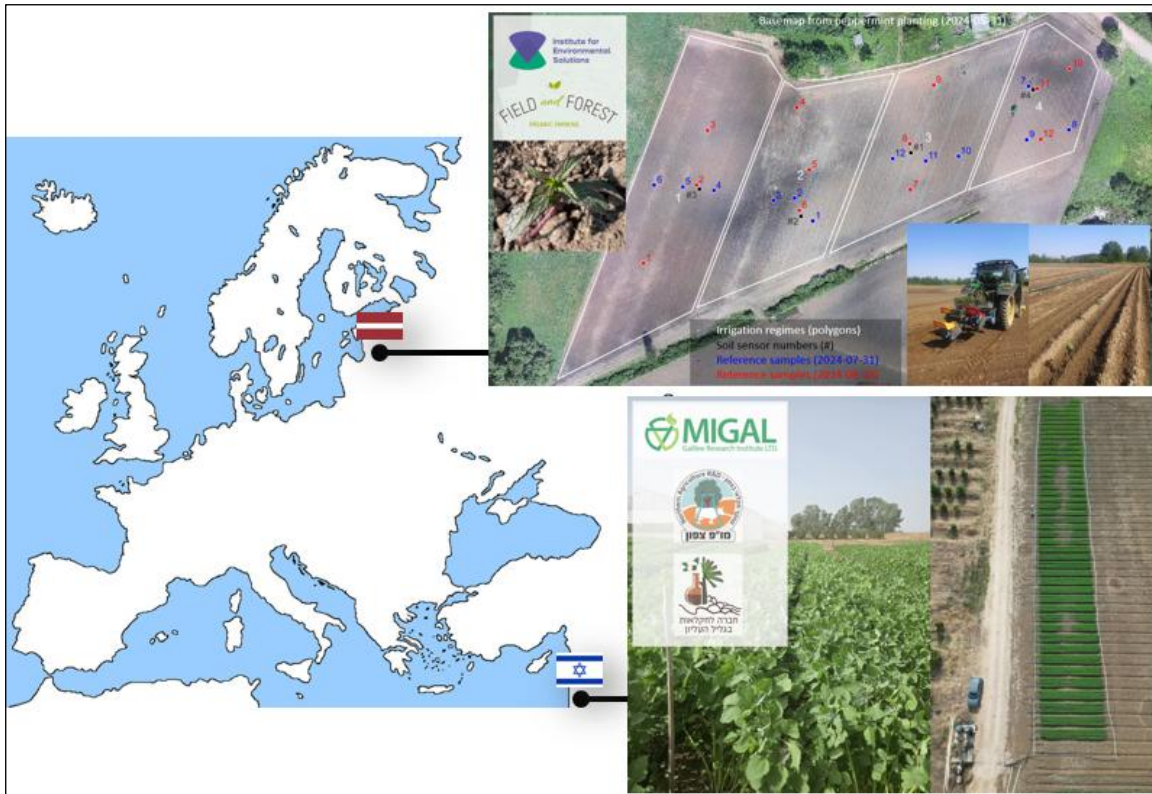


Figure 3: Location of demonstration sites

3.3.1.7 Primary End-users

Small-scale farmers – demonstrators are performed in close collaboration with local farmers to ensure real environment and challenges.

3.3.1.8 Target Groups

Agricultural consultants

3.3.1.9 User Needs and Expectations

Users are interested in a reliable and cost effective approach to assess field water status. Soil moisture sensors provide accurate data on soil moisture which could be directly converted into field water status, however, such an approach is expensive. Therefore, there is of interest to understand and test how other data sources, e.g. meteorological stations, or remote sensing / EO data, might provide reliable field water status assessment on a larger scale.

3.3.1.10 Evaluation Objectives

The main objective was to understand how sensor data could help to assess field water status and support irrigation planning as well as possibilities to upscale approach using EO data products.

3.3.1.11 Evaluation Approach

Field water status obtained from soil moisture sensors was used as reference data for evaluation of other approaches. Currently, correlation between reference data and alternative approach data was chosen as a metric for evaluation of suitability.

The evaluation integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation.

3.3.1.12 Key Performance Indicators (KPIs)

R² representing correlation between reference data and proposed approach.

Additional KPIs should be determined in collaboration with farmers to be used during cropping season 2025.

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Number of Distinct Geographical Regions Where the Drought Stress Detection and Prediction Data Product Has Been Successfully Adapted and Validated

, with an planned 2 distinct regions (Latvia and Israel) covered by demonstrators. The first-year data has been collected, but demonstration has been performed only in Latvia so far. Full adaptation and validation are planned for the second iteration in 2025. This supports cross-regional data sharing and knowledge exchange, enhancing the applicability of digital solutions in agriculture and aligning with European policies.

KPI 2: Number of Stakeholders Participating in Workshops or Demonstrations on Drought Stress Detection and Irrigation Optimization

A successfully achieved effect is observed, 3 farming companies involved in implementing demonstrators. Previously, these companies had not practiced irrigated cultivation of selected crops. Demonstrations took place in Latvia and Israel, covering organic farming, quinoa seed cultivation, and diverse crop production. Workshops have facilitated broader knowledge sharing, increasing awareness among farmers, agronomists, and policymakers on drought stress detection and irrigation management, leading to more sustainable water use.

KPI 3: Percentage Decrease in Water Usage for Irrigation

A favorable effect is estimated, with an estimated 10-20% reduction in water usage. Currently, irrigation decisions are based on visual field assessment and farmers' subjective experience, making optimization difficult. While the first iteration did not demonstrate irrigation planning improvements, the second iteration is expected to validate efficiency gains. Improved data-driven decision-making will enhance drought preparedness and water resource management, increasing community resilience to climate change.

KPI 4: Percentage Increase in Yield per Hectare

A favorable effect is estimated, with a estimation of 10-20% increase in yield per hectare. The first iteration did not allow yield optimization demonstration, as peppermint stands in Latvia were not harvested to prioritize root development. However, future trials are expected to confirm improvements in biomass yield and qualitative traits like protein or essential oil content. This will contribute to food security, farm profitability, and increased agricultural resilience in drought-prone areas.

KPI 5: Number of Scientific Publications and Methodological Contributions on Drought Stress Detection and Irrigation Optimization

1 scientific publication planned after the second iteration in 2026. The publication will share findings on drought stress detection and irrigation optimization, contributing to global knowledge in precision agriculture. This will support the scientific community by providing methodological insights and data-driven approaches for sustainable water management in agriculture.

The Drought Stress Detection and Irrigation Optimization initiative contribute to sustainable agriculture and water management, aligning with **EU policies and SDGs**. The adaptation and validation of drought stress detection in multiple regions promote cross-regional knowledge exchange, **enhancing digital solutions for agriculture**. Stakeholder engagement through workshops increases awareness and adoption of data-driven irrigation practices, leading to more **sustainable water use**. The projected 10-20% reduction in water usage supports **SDG 6** (Clean water) by improving irrigation efficiency. Expected yield increases of 10-20% per hectare enhance **food security and farm profitability**, contributing to **SDG 2 (End Hunger)**. The planned scientific publication will advance research in precision agriculture, supporting **global efforts in sustainable water resource management**.

3.3.1.13 Foreseen Risks

There were several issues caused by weather conditions or technical problems which affected initial plans for demonstrator implementation:

- In Latvia, peppermint seedlings were delivered to the farmer in June (initial delivery was planned for beginning of May) and were planted in the mid-June, therefore, data acquisition started only in Jun 18. Late delivery affected the plans of the farmer – it was understood that the first year will be devoted to development of stand roots and yield harvesting is not planned at the end of the season. Therefore, it was possible to focus only on field water status assessment demonstrator. Dry weather continued till the end of July where field irrigation was required only between Jul 10-23. Later on, precipitation exceeded climatic norm and irrigation of fields wasn't required, see graph below.

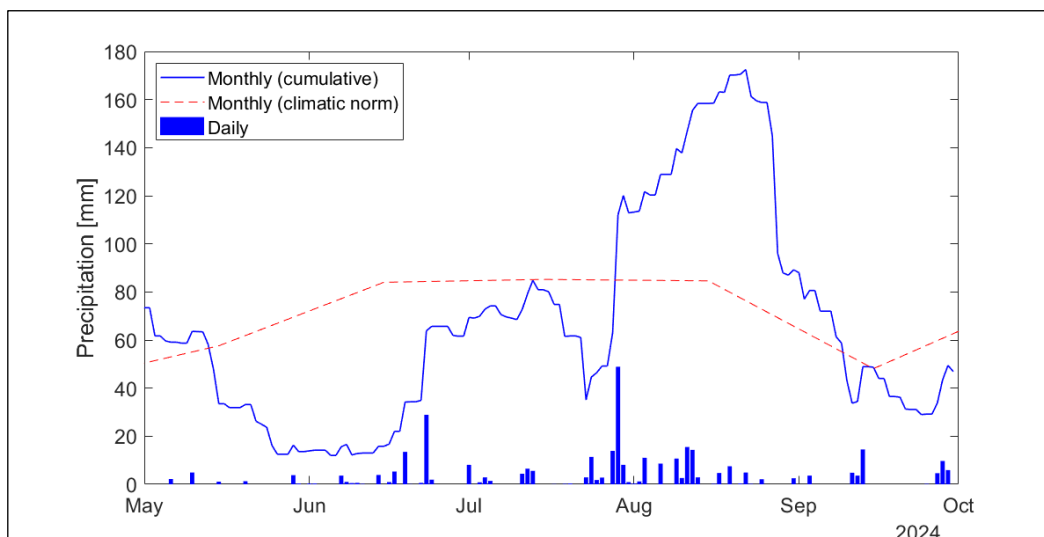


Figure 4: Climatic conditions during 2024 in Latvia demonstration site

- In Israel, a major malfunction in the main water supplying pipe to the experimental farm, caused by a leak outside the farm was encountered. Once discovered and addressed, this resulted in a delay and consequently quinoa could only be sown at the end of July. Due to extremely high soil temperatures and high pest stress during this time period (peak of the summer), seedlings struggled to germinate, causing very low germination and survival rates.

Unpredictable weather conditions will remain the main challenge for successful implementation of the demonstrator as it requires drought caused stress in test fields.

Soil moisture could be measured with different sensors and reading might be affected by soil type. The choice of proper thresholds to initiate irrigation remains a challenge.

EO data products of soil moisture and evapotranspiration provide opportunity to upscale soil water status assessment in a larger area where IoT sensors are not available, however, initial result have shown that there might be challenges with spatial resolution as well as calibration of particular data with reference data.

3.3.1.14 Feedback from participants

Involved farmers are interested in testing the approach for field water status assessment in near-real time during vegetation season 2025 to see how it could improve decision making on irrigation planning.

The initial evaluation of the added value, usability, usefulness took place during the interactive session held as part of the organized demonstration on February 10. Feedback was collected from 16 external stakeholders representing various target groups (see annex3). The key questions addressed and the corresponding responses are as follows:

- Participants were asked which target group they represent, and the largest share (53%) identified as part of the scientific community and academia. SMEs in agribusiness and agritech made up 16%, while policymakers, technology providers, and European institutions each accounted for 5-11%. Farmers and advisors, along with the insurance sector, were not represented. This indicates a

strong interest from researchers and industry professionals but limited engagement from agricultural practitioners and policymakers.

- When asked which climate change challenges they or farmers in their region have faced in recent years, the most commonly reported issues were unpredictable rainfall patterns (73%), more frequent and prolonged droughts (60%), and water shortages with declining groundwater levels (53%). Rising temperatures affecting crop cycles (33%) and increased occurrences of pests and diseases (20%) were also significant concerns. Soil degradation, erosion, and decreased crop yield were mentioned by 13% each. These responses highlight the widespread impact of climate change on agricultural productivity.
- To address drought-caused stress in agriculture, participants were asked which technological solutions seem most appropriate. Smart irrigation systems with automated water control were the top choice (72%), followed by IoT-based soil moisture sensors for precise irrigation (56%) and crop breeding for drought-resistant varieties (50%). AI-driven drought prediction models (33%) and weather forecasting tools (28%) were also considered valuable, while digital decision-support platforms and remote sensing each received lower preference (22-28%). These results suggest that both predictive technologies and precision irrigation methods are seen as crucial in mitigating drought-related risks.
- When discussing preferred sensor-based parameters for monitoring crop water status, 71% of respondents highlighted soil moisture content and evapotranspiration rates as the most relevant factors. Vegetation indices from satellite imagery (59%) and root zone water availability sensors (41%) were also considered important. Sap flow sensors received less attention (12%), while leaf temperature monitoring was not selected. These findings indicate a preference for data that directly measures soil and plant water stress.
- Respondents were also asked how they see this service being most useful. Helping farmers make better irrigation decisions ranked the highest (7.6), followed by improving early warning systems for drought response (6.3) and supporting climate adaptation strategies (5.8). Providing policymakers with data for drought management plans (5.7) and reducing water waste through early drought detection (5.3) were also considered valuable. These insights suggest that decision-making support and early detection are the primary benefits expected from the service.
- Regarding the most important benefits of this service, participants ranked reducing irrigation costs as the top advantage, followed by early detection of drought stress and reducing unnecessary water use. Promoting sustainable farming practices, supporting precision agriculture innovations, and enabling better policy decisions through real-time data were also highly valued. Other benefits included enhancing climate resilience, improving irrigation planning, reducing conflicts over water use, and increasing yield stability to ensure food security. These rankings indicate a strong preference for cost reduction, resource efficiency, and improved decision-making.
- When asked about the biggest challenges in using this service, 50% of participants cited both understanding and interpreting the data, as well as technical issues with system integration. A lack of training and experience with digital tools (44%) and poor internet access in rural areas (38%) were also significant barriers. Limited compatibility with different farm sizes (25%) and data privacy concerns (19%) were additional concerns. These responses highlight the need for user-friendly systems, training support, and improved connectivity for effective adoption.
- Challenges in using this service across different geographic locations were also explored. Climate and soil variations affecting prediction accuracy were the most commonly cited issue (87%), followed by unequal access to technology in different regions (60%) and limited access to localized satellite and weather data (47%). Differences in local regulations and data-sharing policies (33%)

and the high cost of necessary sensors and infrastructure (27%) were also noted. These findings emphasize the importance of regional customization and accessibility to ensure scalability.

- Participants were asked what improvements would enhance the usability of the service. The highest priority was integrating the service with existing farm management systems (75%), followed by automated recommendations for farmers and policymakers (63%). A mobile-friendly app for real-time alerts (50%) and support for multiple languages (31%) were also identified as key enhancements. More visual and simplified reports (25%) were seen as beneficial, indicating a need for clear, actionable insights. These responses highlight the importance of seamless integration, automation, and accessibility in improving the service's effectiveness.
- Finally participants were asked what would make this service more adaptable to different geographic locations, and the most preferred solution was easier integration with existing irrigation and farm management tools, selected by 75% of respondents. More localized datasets and satellite imagery were also considered essential by 69%, while 56% highlighted the need for customization based on regional climate and soil conditions. Improved data-sharing policies with clear privacy protections were mentioned by 44%, and 13% emphasized the importance of offline functionality for areas with weak internet access. These responses suggest that seamless integration, regional adaptability, and data accessibility are key factors in enhancing the usability of the service across different locations.

3.3.1.15 Future Developments Planned Improvements for 2nd Iteration

Data acquisition will continue for chosen crop types in two regions:

- In Latvia, it is expected that grow-in phase of peppermint will be completed and the farmer will focus on the yield production using provided field water status to plan irrigation in test fields; however, it is not known how bare frost in Feb 2025 will affect peppermint stand survival.
- In Israel, the 2nd iteration, i.e. 2nd season of Quinoa growth will be conducted outside the experimental farm, at a new location in a private farm but still in the same region.

In both regions, soil sensor data will be used to plan irrigation, thus demonstrating the application of field water status in a near-real time environment. If EO data products will be provided in a near-real time regime, their application for irrigation scheduling will be also tested.

The main focus of the second year will be yield reference data gathering to demonstrate difference in yield quantity and quality for different irrigation regimes.

3.3.1.16 Scalability and Replication

It will be tested how similar principles for field water status assessment and yield prediction could be applied in two different and distant regions – Latvia and Israel.

Testing of EO data products could potentially allow upscaling of field water status and yield prediction from field with IoT sensors to the other ones.

3.3.2 RIL2a.1 – Policy Monitoring Tool

3.3.2.1 Demonstrator Overview

Thematic focus: Crop monitoring.

Main Objectives:

- to empower policymakers in making data-driven decisions and assess the impact of agricultural policies across regions more effectively by providing tools that aggregate and analyse IoT and farm log data from farm level at a regional level.
- to support policy makers in the monitoring of the sustainability KPIs of the Common Agricultural Policy (CAP) through the collection of data from the automatic pesticide detection sensor.
- to enhance advisory services for farmers through advanced data aggregation, assimilation, and fusion techniques, maximizing the reach of IoT sensor networks.

3.3.2.2 General Description

The **Policy Monitoring Tool** provides policymakers with a dynamic dashboard for monitoring and analyzing agricultural policies. This tool generates comprehensive analytical reports, including summary tables and graphical charts, based on user-defined queries. The tool integrates data at the regional level (Group of Parcels or Local Administrative Unit or Commune) from the **ScaleAgData** project, which includes anonymized and aggregated in-situ data from parcels using Digital Agriculture Technologies (DATSs), non-DATS parcels, farm calendars, and digital logs.

To enhance decision-making, the tool combines Earth Observation (EO) data, such as crop types and land use, with open European GIS datasets (e.g., GISCO, EEA) and EU policy monitoring services (e.g., FADN, Eurostat). These inputs allow the calculation of key performance indicators (KPIs) and relevant variables, providing both qualitative and quantitative insights into regional agricultural performance. By offering a platform that aggregates, assimilates, and analyzes diverse data sources, the Policy Monitoring Tool helps policymakers make informed decisions, assess the effectiveness of policies, and monitor the sustainability of agricultural practices aligned with the Common Agricultural Policy (CAP).

3.3.2.3 Technologies Used

The following technologies were used within the demonstrator:

IoT Sensor Networks: The demonstrator integrates data from IoT-enabled devices deployed on farms, capturing real-time information on soil conditions, weather, crop growth, and other relevant agricultural metrics. These sensors are critical for monitoring parcels utilizing Digital Agriculture Technologies (DATSs).

Earth Observation (EO) Data: Satellite-based EO data, including crop type classifications and land use information from sources such as ESA (European Space Agency), are utilized for large-scale agricultural monitoring. These data products support the generation of key performance indicators (KPIs) and regional performance analysis.

Geographic Information System (GIS) Platforms: The demonstrator leverages QGIS and other open GIS platforms to visualize and analyze spatial data. This includes integrating datasets from GISCO and

EEA (European Environment Agency) for mapping and geospatial analysis at the local and regional levels.

Data Aggregation and Fusion: Advanced techniques for data aggregation, assimilation, and fusion are applied to combine diverse data sources, including IoT sensors, EO data, and open European datasets. This enables comprehensive analysis and reporting of agricultural performance and policy impact.

EU Policy Monitoring Services: The demonstrator uses data from FADN (Farm Accountancy Data Network) and Eurostat to calculate CAP-related sustainability KPIs and perform comparative analysis across regions.

Farm Management Systems and Digital Logs: Collaborations with technical providers offer integration with farm management software, exporting data such as farm calendars and digital logs to enhance decision support for farmers and policymakers.

Collaborations: Key technical providers within ScaleAgData include DHI, LUKE, ICCS and VITO which offer data products relative to RIL2a's scope of work.

3.3.2.4 Deployment Information - Timeline

The demonstrator is currently under development, with a phased deployment plan:

First Iteration (Early 2025): The initial version of the demonstrator is expected to be ready in the first months of 2025. This phase will focus on data aggregation at the farm level, extending to group of parcels level. It will integrate and display data from Digital Agriculture Technologies (DATSs), in-situ sensor networks, and other relevant sources, providing a foundation for monitoring agricultural activities on a smaller scale.

Second Iteration (End-2025): In the second iteration, the demonstrator will expand its capabilities to estimate agricultural indices at the regional level. This will involve scaling up the data aggregation and processing techniques to cover broader geographical areas, offering more comprehensive insights for regional policy monitoring and decision-making.

These iterations will provide a progressive enhancement of the demonstrator's functionalities, moving from farm-level monitoring to more sophisticated regional analysis. The final deployment is expected to incorporate feedback from the first iteration and focus on further refining the tool for broader use.

3.3.2.5 Integration with Existing Systems

The demonstrator will be seamlessly integrated into the end-user applications developed by NP as part of European projects, such as Quantifarm. It will function as an upgraded version, building on previous developments with enhanced capabilities and features. Key improvements include:

1. Aggregation at the Group of Parcels Level:
2. Incorporation of Pesticide Sensor Data:
3. Incorporation of data products produced through the collaborations with Technical Providers, such as Digital Twin Technology and Soil Moisture Estimation.

3.3.2.6 Deployment Locations

The demonstrator will be deployed across farms cultivating four key crop types: potato, tomato, cotton, and wheat. These farms are situated in prominent agricultural regions of Greece, specifically in

Thessaly, Kilkis, and Crete. These locations have been strategically selected for their significance in Greece’s agricultural production, providing diverse environmental conditions and farming practices that will enable comprehensive testing and evaluation of the demonstrator's capabilities across different crop types and regions. The deployment aims to assess how the demonstrator performs in real-world settings, ensuring adaptability to varying agronomic and geographic conditions.



Figure 5: Location of pilot parcels (a) T1 - T3,C1 - C3 and their respective commune boundaries and (b) P1 – P2 and their respective commune boundaries

3.3.2.7 Primary End-users

1. **Policymakers:** The primary users of the demonstrator are policymakers responsible for agricultural policy design, implementation, and monitoring, especially those involved in the Common Agricultural Policy (CAP). They use the tool to monitor sustainability KPIs, assess the impact of policies, and make data-driven decisions at regional and national levels.
2. **Farmers and Agricultural Co-operatives:** Small and medium-scale farmers, as well as agricultural cooperatives, are key end-users. The demonstrator provides insights into their farm management practices by integrating IoT sensor data, farm calendars, and pesticide usage, helping them optimize resources and comply with sustainability guidelines.
3. **Agricultural Consultants:** Consultants who advise farmers on improving productivity, resource use, and compliance with agricultural policies benefit from the demonstrator by accessing data on soil moisture, pesticide usage, and other environmental parameters to offer informed recommendations.

3.3.2.8 Target Groups

1. **Environmental Agencies:** Environmental monitoring agencies use the tool to track the environmental impact of farming activities, such as pesticide use and water consumption, ensuring that agricultural practices align with sustainability goals and regulations.
2. **Research Institutions:** Agricultural researchers and institutions are also primary users, utilizing the tool to analyze data, conduct studies on crop performance, and evaluate the environmental and economic impact of various agricultural technologies and practices.
3. **Technical Providers:** Companies offering digital agriculture solutions, including IoT sensor

networks and digital twin technology, interact with the demonstrator to showcase the effectiveness of their technologies in real-world scenarios, improving their offerings based on insights from the tool.

4. Agricultural Associations and NGOs: Farmers' associations, NGOs, and advocacy groups focused on sustainable agriculture can use the data from the demonstrator to promote best practices and influence agricultural policy at both local and regional levels.

3.3.2.9 User Needs and Expectations

- **Farmers** need a summarized overview of the cultivation practices on their parcels and the ability to compare them with neighboring parcels. This comparison will provide actionable insights, helping them optimize their farming practices and the use of available resources. By understanding how their practices measure up to local benchmarks, farmers can make more informed decisions on irrigation, fertilization, and crop management, ultimately improving productivity and sustainability.
- **Farmers** also benefit from receiving monthly summaries of their registered cultivation practices, allowing them to compare with data from previous years. This enables them to track performance, identify trends, and make data-driven adjustments to enhance productivity and sustainability over time.
- **Policymakers** require detailed information on pesticide and fertilizer use within administrative areas on a monthly or yearly basis. This data is essential for monitoring the implementation of sustainability-related CAP policies and for preparing reports for environmental authorities, ensuring compliance with environmental regulations and supporting informed decision-making.
- **Agronomists** and advisors need an application that allows them to select specific parcels and view aggregated data on pesticide use. This functionality helps them provide more precise advice to farmers, enabling better decision-making around pesticide application and aligning practices with sustainability goals. The demonstrator facilitates this by offering comprehensive, parcel-level insights into pesticide usage trends.

3.3.2.10 Evaluation Objectives

The evaluation aims to assess the Policy Monitoring Tool's performance, usability, and impact. Key aspects include its effectiveness in aiding data-driven decision-making for policymakers, the accuracy and relevance of aggregated data, user satisfaction among farmers and advisors, and alignment with the Common Agricultural Policy (CAP) sustainability goals.

3.3.2.11 Evaluation Approach

Our evaluation integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external

stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation

3.3.2.12 Key Performance Indicators (KPIs)

The achievement of the following KPIs is currently in progress, driven by the ongoing development of the demonstrators. These efforts contribute to key project objectives, including the implementation and applicability of innovative technologies, data sharing best practices, and the development of improved data products and Smart Farming solutions.

- KPI.O1: Implementation of sensor and sampling innovations – in progress
- KPI.O2: Applicability of sensors – in progress
- KPI.O4: Adoption and demonstration of data sharing best practices – in progress
- KPI.O7: Development of improved or new data products – in progress
- KPI.O8: Utilization of improved data products by RILs to optimize services to farmers
- KPI.I1: Newly developed Smart Farming solutions
- KPI.I2: Regions where these solutions were tested.
- KPI.I3: Engaged potential users for all Smart Farming-related data products.
- KPI.I4: Agri-environmental soil and crop parameters covered.
- KPI.I5: Regions where these solutions were tested.
- KPI.I6: Engaged potential users for each soil and crop-related data product.
- KPI.I17: Co-design workshops.

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Increase in Advisors'/Policy Makers'/Farmers' Interest in Using the Data Product

With a confirmed target of three end user showing interest in using the data product. By providing agri-environmental monitoring tools, policymakers and advisors can enhance productivity and improve decision-making. This will support more efficient agricultural practices, enabling better resource allocation and policy development. The social and economic benefits include higher productivity for advisors and improved decision-making capabilities, leading to more informed farming practices.

KPI 2: Decrease in Pesticide Usage

A favorable effect is estimated, with a projected reduction in pesticide use. Agri-environmental monitoring tools can support farmers in making more precise decisions about pesticide application, reducing overuse and minimizing environmental pollution in soil and water. This can enhance food quality and safety while also lowering costs for farmers, ultimately contributing to increased income and sustainable farming practices. The social and economic impact includes improved environmental conditions and cost-effective crop management.

KPI 3: Creation of Datasets for Further Scientific Research

A favorable effect is expected, with an anticipated increase in quality datasets available for research. By increasing existing agricultural data, researchers and tech providers can advance scientific studies related to sustainable farming, climate impact, and AI-driven analytics. The primary impact is scientific, supporting innovation in agricultural technology and policy development through data-driven insight.

KPI 4: Decrease in Time for Monitoring Sustainability KPIs of the Common Agricultural Policy (CAP)

A favorable effect is expected, with a projected reduction in the time required to monitor sustainability indicators. The use of agri-environmental monitoring tools can improve efficiency, allowing advisors to manage their work more effectively while reducing administrative burdens. This will contribute to better work management and increased efficiency in implementing sustainability measures, ultimately benefiting both advisors and policymakers in the agricultural sector.

Developed Agri-environmental monitoring tool can contribute to **sustainability and competitiveness** by improving agricultural decision-making and resource management. Increased interest from advisors, policymakers, and farmers can enhance the adoption of data-driven tools, leading to more efficient farming and policy development. Reduced pesticide use supports **SDG 6 (Clean Water)** and **SDG 12 (Sustainable Consumption)** by minimizing **environmental pollution** and improving **food safety**. The creation of datasets for research advances scientific innovation in sustainable farming and climate impact analysis, aligning with the European **Green Deal**. Faster monitoring of CAP sustainability indicators improves policy efficiency, strengthening the implementation of sustainable agricultural practices.

3.3.2.13 Foreseen Risks

The following risks and the corresponding measures for mitigation have been identified:

Data Integration Challenges: Difficulties in aggregating diverse data sources may affect tool performance.

Mitigation: Implement robust data standardization protocols and ensure compatibility across systems.

User Adoption Resistance: Stakeholders may be hesitant to adopt new technologies.

Mitigation: Conduct comprehensive training sessions and provide continuous support to ease the transition.

3.3.2.14 Feedback from participants

The initial evaluation of the added value, usability, usefulness took place during the interactive session held as part of the organized demonstration on February 10. Feedback was collected from external stakeholders representing various target groups (see annex 3). The key questions addressed and the corresponding responses are as follows:

- Participants were asked to identify the target group they represent. The largest share, 38%, comes from the scientific community and academia, indicating strong research involvement. Farmers, advisors, and their associations account for 35%, reflecting direct engagement from those actively working in agriculture. SMEs, agribusinesses, and agritech companies make up 31%, highlighting

significant industry participation. Other groups, including technology providers (12%) and the insurance sector (8%), also play a role, while policymakers (4%) and general public consumers (4%) are less represented.

- The perceived value of aggregating farm log data at a regional level for advanced crop monitoring and policy decision-making is notably high, with an average rating of 4.5 out of 5. This indicates a strong consensus on the benefits of data aggregation in enhancing decision-making processes in agriculture.
- The tools for agri-environmental monitoring, decision support systems, and early pest detection are expected to benefit different groups. Farmers stand out as the primary beneficiaries (100%), followed by policymakers (67%) and agricultural consultants (67%). Researchers (33%), environmental agencies (17%), and other stakeholders (17%) also see potential value. These insights highlight the broad applicability of these tools across the agricultural and policy landscape.
- The tools presented are perceived as most useful for monitoring agricultural policies and sustainability, as well as supporting farmers with data-driven decisions, with both purposes receiving 100% agreement. Other significant benefits include reducing the environmental impact of farming (50%) and improving food security and crop productivity (33%).
- Beyond the primary target groups, additional beneficiaries of these tools include local governments (100%), food industry and supply chain managers (83%), and NGOs advocating for sustainable farming (67%). Climate change researchers (17%) were also mentioned, suggesting that the technology has relevance across multiple sectors.
- The biggest challenges in using such services revolve around data privacy and security concerns (67%), followed by limited compatibility with existing systems (50%). Other concerns include the complexity of the system, high costs, and the uncertainty of how insights can be effectively applied.
- Improvements that could enhance the practicality and adoption of these tools include better integration with existing farm management systems (60%), clearer data privacy policies (60%), and stronger collaboration with policymakers and farmers (40%). Other suggested improvements include increased training and customization for different users.
- The potential benefits these services could provide include helping farmers manage crops more efficiently (100%), improving crop yields (80%). Other key advantages include reducing costs for farmers.

3.3.2.15 Future Developments Planned Improvements for 2nd Iteration

For the second iteration, efforts will be directed towards improving the aggregation results of the demonstrator and scaling data from the regional level to the administrative level. Additionally, the evaluation will assess the usefulness of data products provided by the project's technology partners to ensure their relevance and applicability.

3.3.2.16 Scalability and Replication

The tool is designed with scalability in mind, allowing for deployment in various regions beyond the initial pilot areas. Its modular architecture facilitates adaptation to different agricultural contexts and policy frameworks, enabling replication in other EU member states.

3.3.2.17 8. Supporting Materials - Images/Diagrams

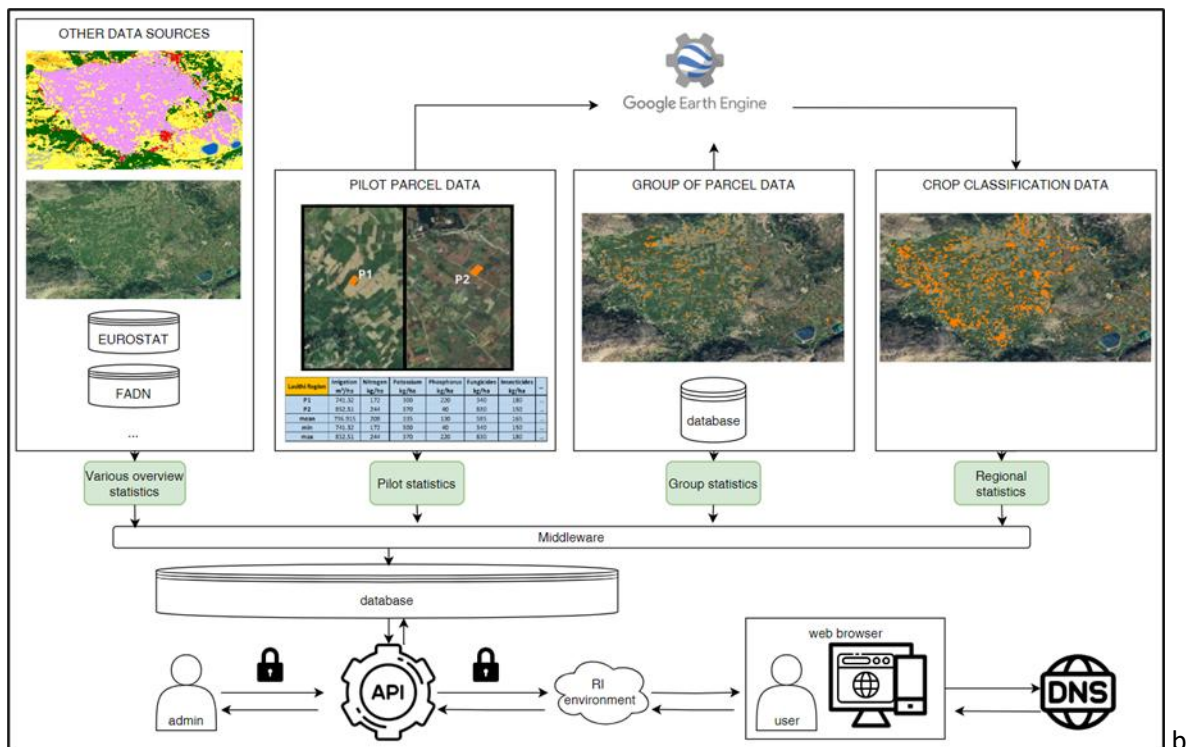
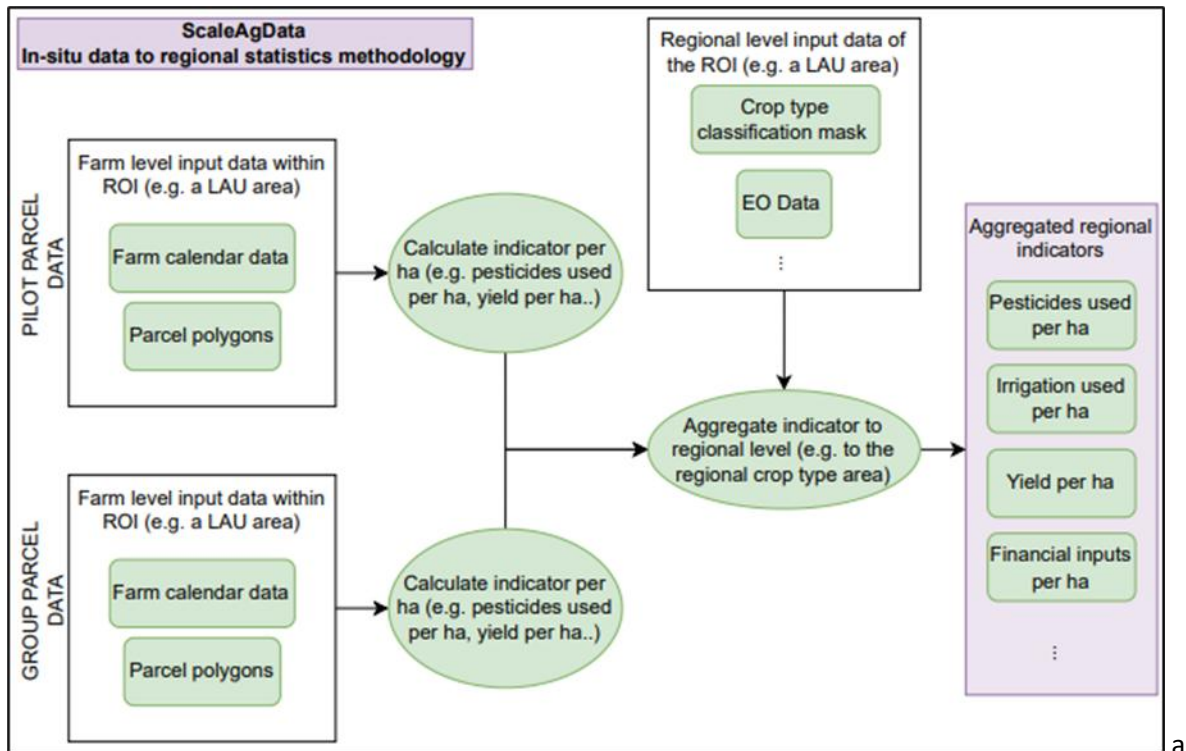


Figure 6 a, b.: Methodology outline of demonstrator.

3.3.2.18 Relevant Documentation

There are no further relevant documents.

3.3.3 RIL2b.1 – Sustainability monitoring - grano.net®

3.3.3.1 Demonstrator Overview

Thematic focus: Crop management – sustainability.

Main Objective: The Decision Support System grano.net® provides farmers with decision support in their daily management of wheat crops, relying on the use of weather data measured by in situ weather station, soil information and crop management action provided from the farmers. In order to further improve the system, Horta evaluated the integration of earth observation data for better crop monitoring and more precise inputs. In particular, the use of earth observation data of NDVI as input for the phenological and yield forecasting model were evaluated.

The DSS has also available a functionality for the calculation of sustainability Key Performance Indicators (KPI), allowing to evaluate the crop management technique.

3.3.3.2 General Description

The DSS grano.net® is a web based tool for farmer to improve their management of wheat crops. The DSS provides support for the main phases of crop management, such as sowing, phenological development, fertilisation interventions, main crop diseases, abiotic stresses, yield forecasts. In the frame of ScaleAgData RIL Lab 2b, focus was put on the use of earth observation data for the improvement of the currently available models in the DSS. The main work carried out was aimed at the use of NDVI data as input for the wheat phenological models, and in the yield forecast. Moreover, the potential use of new indexes provided from project partners, has started to be evaluated.

3.3.3.3 Technologies Used

In situ weather data (Temperature, Relative Humidity, Rain, Leaf wetness) from weather stations, soil data, farm log, Earth observation data (NDVI) retrieved from a commercial provider. Moreover, yield potential index provided from VITO, Evapotranspiration and soil moisture index provided from DHI were retrieved for the monitored fields.

3.3.3.4 Deployment Information - Timeline

In the first iteration, the demonstrator deployment was carried out up to M24 in the project. In the second iteration more analysis will be carried out on the use of earth observation data in the improvement of the DSS functionalities.

3.3.3.5 Integration with Existing Systems

The demonstrator is part of the existing DSS grano.net®, as the deployed work was aimed to evaluate the potential improvements the available DSS provided from the use of earth observation images. Moreover, sustainability indexes were calculated for all the plots monitored for the sub lab activities.

3.3.3.6 Deployment Locations

The SubLab activity involved 14 wheat fields grown in the 2023-24 cropping season in the western part of the Emilia-Romagna region, in the North of Italy, for a total surface of 478 ha. Specifically, the

fields were located in the Bologna, Ravenna, Ferrara, Forlì-Cesena provinces. The fields were monitored by retrieving in situ data from a total of 10 weather stations located in the proximity of the fields.

The map of Italy displayed below (Figure 4) indicates with a red square the geographic area of deployment of the SubLab 2b activities, which focus on the wheat crop. The area selected is part of the Emilia-Romagna region, which in total hosts 53,000 farms, representing 4.7% of the total National farms. The utilised agricultural surface cover the 47.2% of the regional surface. Most of the agricultural area is dedicated to arable crops (82.9%), followed by woody crops (10.9%, mainly grapevine and fruit trees). Arable crops cover a total surface of 877.000 ha, of which 38.2% is dedicated to grain cereals. Livestock is also important in the regional agriculture, representing 17.5% of the national production for poultry, 11.6% for pigs and 10.3% for cattle.

Farms in Emilia-Romagna are also sensitive to technical improvements, with more than 22% of them having invested in innovation in the years 2018-2020 (National average is 11%).

Wheat production in 2024 in Emilia-Romagna occupied a surface of 131,521 ha, and led to 780,602 t of harvested grain. The four provinces considered in 2024 hosted a total of 76,406 ha of wheat, producing 48,0552.5 t of grains, thus contributing to almost 60% of the regional production.

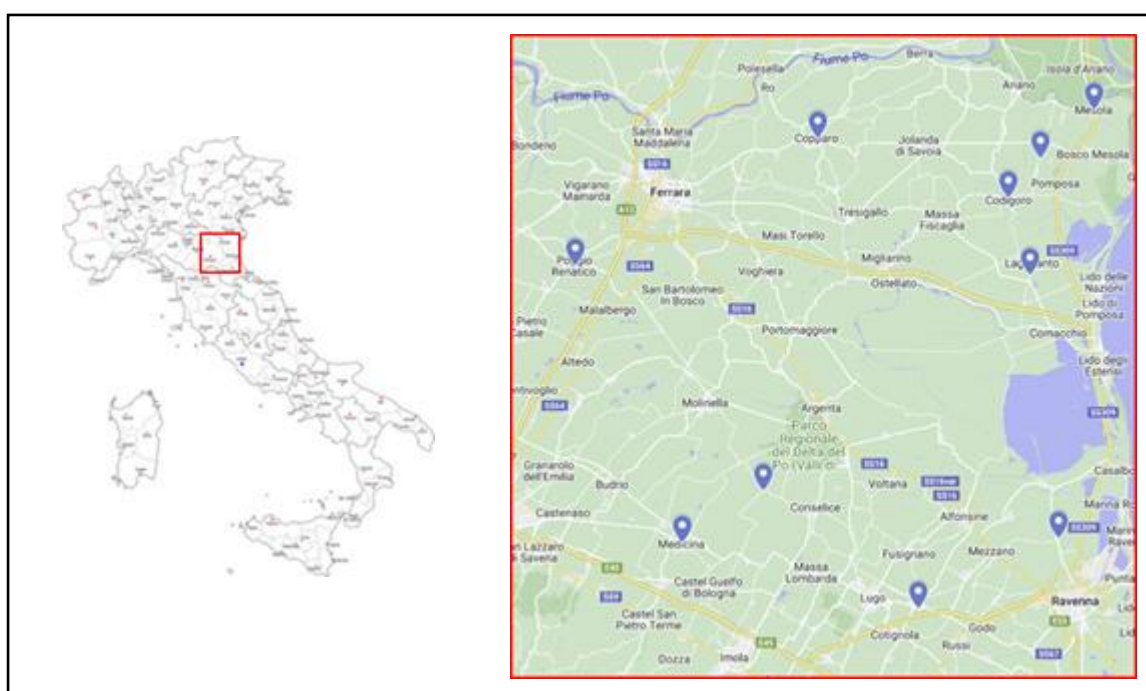


Figure 7: Maps displaying the area of interest of the SuBLab 2b activities: map of Italy, displaying in a red square the area addressed from SubLab 2b activities (right); and a detailed map of the area displaying the location of the monitored weather stations (left), which are close to the monitored fields.

3.3.3.7 Primary End-users

Primary end users of the grano.net[®] DSS are farmers, which need to efficiently manage their crops in the fields, as well as technicians and agronomists supporting the farm activities. The tool helps them by providing decision support in the main phase of the cropping cycle, as well as providing a tool for crop monitoring. Moreover, the tool allows to calculate sustainability indexes, providing additional guidance for the implementation of less impacting activities.

3.3.3.8 Target Groups

In addition to the primary users, the demonstrator can also be useful for policy makers, which can monitor the risks for crop pest and diseases development, which can be a valid support for the issue of phytosanitary bulletins. Policy makers can also benefit from the calculation of sustainability KPIs, which could allow them to assess the environmental impact deriving from agricultural activity. Insurance companies can also be a potential stakeholder, for example for parametric products, which can rely on predictions deriving from robust models.

3.3.3.9 User Needs and Expectations

Farmers need an improved digital tool supporting them in the decision-making process in regards to the management of their wheat crop. Such a digital tool is expected to allow them to optimise technical inputs in their fields, such as seeds, fertilisers, water, and to improve yield and quality of the harvested product. The evaluation done in the frame of the project opens the potential improvements of the wheat yield forecasting model by using earth observation data as model input. In particular, the analysis highlighted the fact that the present inner sub-model predicting LAI (Leaf Area Index) development can be substituted by LAI values deriving from satellites. In the simulations performed, this resulted in a higher index of agreement among measured and predicted values. This is particularly true in cases where unforeseen accidents (such as flooding, wild animals) damage the crop canopy, thus improving the monitoring value of the digital tool.

3.3.3.10 . Evaluation Objectives

The evaluation process aimed to assess the potential usefulness for the user of the DSS grano.net[®], and their opinion on the potential improvements deriving from the use of earth observation data, and the interest in having sustainability KPIs available in the tool (Figure 5).

3.3.3.11 Evaluation Approach

The evaluation of the improvement of the model thanks to the new input data was evaluated by agronomists at Horta.

The evaluation of impact and added value was done integrating quantitative and qualitative methods. The impact assessment is based on initial KPIs defined in the Grant Agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions. The added value assessment was performed by mean of structured questions developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation.

In particular, the evaluation from stakeholders was obtained in an online demonstration event, organised by the ScaleAgData project and common to various RILs, in order to gather feedback from a composite stakeholders group, coming from different geographical areas.

3.3.3.12 Key Performance Indicators (KPIs)

The SubLab is contributing to the following KPIs for impact, as defined in the Grant Agreement:
Topic Outcome 2: Strengthening capacities for agri-environmental (climate) monitoring, particularly of soil and crop conditions

KPI.I4: Number of agri-environmental soil and crop parameters covered.

KPI.I5: Number of regions where these solutions will be tested.

Wider Impact 5: More informed and engaged stakeholders and end users including primary producers and consumers thanks to effective platforms such as Agriculture Knowledge and Innovation Systems (AKIS)

KPI.I17: Number of co-design workshops.

Contributions to Wider Impacts

Additional KPIs have been then developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: % Increase in Advisors/Policy Makers/Farmers' Interest in Using the Data Product

Targeted **5% increase** in the number of advisors and farmers engaging with the Decision Support System. Historical data from the Emilia-Romagna region serves as the baseline, and the increase in crop units created in the DSS indicates improved adoption. This will enhance productivity for advisors, lead to better decision-making, and strengthen economic and social outcomes in precision farming.

KPI 2: % Decrease in Pesticide Use per Hectare

A very favorable effect is projected, targeted **20% decrease** in the amount of plant protection products used in wheat crops. Historical data on plant protection products usage serves as the baseline, and improved decision-making through the DSS will allow for more precise and targeted applications. This will enhance food safety, reduce environmental pollution, lower production costs, and contribute to higher farmer incomes.

KPI 3: Number of Treatments from Field Reports

Targeted **10% decrease** in the number of plant protection product applications per year. Field reports provide the baseline, and the Decision Support System is expected to optimize treatment schedules, reducing unnecessary pesticide use. This will contribute to lower costs, improved food quality and safety, and a positive environmental impact by minimizing soil and water pollution.

KPI 4: % Decrease in Crop Reduction / % Increase in Yield per Hectare

Targeted **5% increase** in crop yields per hectare. Historical data from the DSS-managed crop units serves as the baseline, and improved decision-making will enhance productivity and resource efficiency. This will result in better food availability, increased farm profitability, and improved food security at both the local and regional levels.

KPI 5: Increase in Datasets for Further Scientific Research

A favorable effect is expected, with datasets generated from monitoring 10 wheat parcels per cropping season. Expert judgments and survey assessments indicate that the Decision Support System will enable systematic data collection, supporting advanced agricultural research and innovation in precision farming techniques. This will enhance scientific knowledge and facilitate better data-driven decision-making in the agricultural sector.

KPI 6: % Decrease in Travel Time for Inspection Activities

Targeted **10% decrease** in the time advisors and farmers spend on field visits for crop inspections. Historical data on current inspection times serves as the baseline, and the Decision Support System

will optimize monitoring efforts, reducing the need for frequent in-person checks. This will enhance efficiency, improve work management, and allow farmers and advisors to allocate their time more effectively

KPI 7: % Decrease in Time for Monitoring Sustainability KPIs of the Common Agricultural Policy (CAP)

A very favorable effect is expected, as the Decision Support System will streamline sustainability monitoring processes, reducing the time required for compliance checks. Expert evaluations suggest that automated calculations based on collected data and farm logs will improve efficiency, enabling advisors to focus on more strategic aspects of agricultural planning. This will enhance sustainability efforts while reducing administrative burdens.

Developed solution can contribute to sustainability and competitiveness by improving decision-making, resource efficiency, and environmental protection in agriculture. Increased engagement from advisors, policymakers, and farmers enhances the adoption of data-driven tools, leading to better precision farming practices and economic benefits. A reduction in pesticide use and application frequency minimizes environmental pollution, supports **SDG 6 (Clean Water)** and **SDG 12 (Sustainable Consumption)**, and lowers production costs while improving food safety. Higher crop yields per hectare strengthen food security and farm profitability, aligning with the European **Green Deal and Farm to Fork Strategy**. Expanded datasets for scientific research drive innovation in precision agriculture, supporting policy development and technological advancements. Reduced travel time for inspections and streamlined sustainability monitoring under **the CAP improve efficiency**, and allow advisors and farmers to focus on more strategic planning.

3.3.3.13 Foreseen Risks

The availability of satellite data is key for the studies carried out under the SubLab, so the lack of those data or the unsuitability of the images is an important aspect to be considered.

Availability of ground data is also key, so for the following cropping season new parcels need to be identified, as wheat is usually grown in rotation in North Italy.

3.3.3.14 Feedback from participants

The initial evaluation of the added value, usability, usefulness took place during the interactive session held as part of the organized demonstration on February 10th 2025. Feedback was collected from external stakeholders representing various target groups. The key questions addressed and the corresponding responses are as follows:

- The analysis of target groups represented in the study highlights a diverse range of stakeholders involved in agricultural innovation. The largest share, 38%, comes from the scientific community and academia, demonstrating strong interest from research institutions. Farmers, advisors, and their associations make up 35%, indicating practical engagement from those directly involved in agriculture. SMEs, agribusinesses, and agritech companies account for 31%, showing significant industry participation. Other groups, such as technology providers (12%) and the insurance sector (8%), also play a role, while policymakers (4%) and general public consumers (4%) are less represented. European institutions do not appear in the responses.

- The usefulness of a decision support system, similar to the one presented, is rated at 4.3 out of 5. This suggests that such systems are considered valuable, though some refinements may be necessary to maximize their effectiveness for end users.
- The tools for agri-environmental monitoring, decision support systems, and early pest detection are expected to benefit different groups. Farmers stand out as the primary beneficiaries (100%), followed by policymakers (67%) and agricultural consultants (67%). Researchers (33%), environmental agencies (17%), and other stakeholders (17%) also see potential value. These insights highlight the broad applicability of these tools across the agricultural and policy landscape.
- The tools presented are perceived as most useful for monitoring agricultural policies and sustainability, as well as supporting farmers with data-driven decisions, with both purposes receiving 100% agreement. Other significant benefits include reducing the environmental impact of farming (50%) and improving food security and crop productivity (33%).
- Beyond the primary target groups, additional beneficiaries of these tools include local governments (100%), food industry and supply chain managers (83%), and NGOs advocating for sustainable farming (67%). Climate change researchers (17%) were also mentioned, suggesting that the technology has relevance across multiple sectors.
- The biggest challenges in using such services revolve around data privacy and security concerns (67%), followed by limited compatibility with existing systems (50%). Other concerns include the complexity of the system, high costs, and the uncertainty of how insights can be effectively applied.
- Improvements that could enhance the practicality and adoption of these tools include better integration with existing farm management systems (60%), clearer data privacy policies (60%), and stronger collaboration with policymakers and farmers (40%). Other suggested improvements include increased training and customization for different users.
- The potential benefits these services could provide include helping farmers manage crops more efficiently (100%), improving crop yields (80%), and reducing overuse of pesticides and fertilizers (40%). Other key advantages include reducing costs for farmers, improving water usage monitoring.

3.3.3.15 Future Developments Planned Improvements for 2nd Iteration

For the second iteration, the monitoring of wheat fields will be replicated, as well as calculation of sustainability KPIs, and studies on the added value of the potential use of earth observation data provided from project partners. Moreover, additional attention and effort will be paid in the upscaling of data from single fields to wider areas.

3.3.3.16 Scalability and Replication

The deployment of improvements of models and functionalities is being carried out in the general frame of the DSS grano.net[®], which is a digital tool available in Italy and other countries. Data availability is a key aspect for the scalability of the demonstrator, both in terms of timely updates and in terms of availability for new regions.

3.3.3.17 Supporting Materials - Images/Diagrams

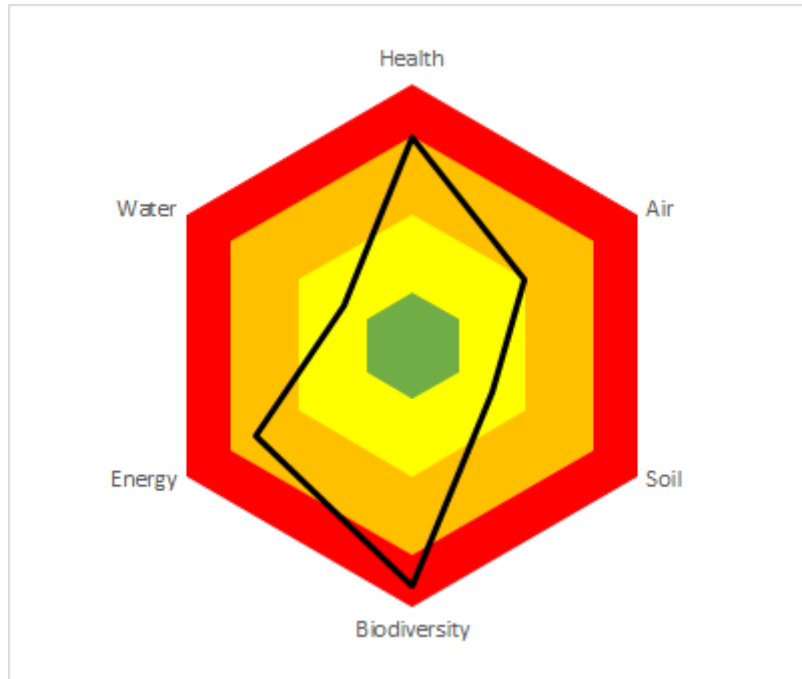


Figure 8: Average of sustainability KPIs for the Human Health, Air, Soil, Biodiversity, Energy and Water compartments, as measured in the monitored fields.

3.3.3.18 Relevant Documentation

There are no further relevant documents.

3.3.4 RIL2c.1 – Crop Management

3.3.4.1 Demonstrator Overview

Thematic focus: Early Pest Detection

Main Objective: Primary goal is to prepare a revised and scaled algorithm for estimating pest occurrence probabilities based on data from meteorological and phenological stations, field observations, farmer input, satellite data and mathematical models

3.3.4.2 General Description

The aim of RIL 2c is to improve the process of notifying farmers of pest incidence. Currently, this process is based on cyclic field observations and mathematical models using actual meteorological data. The current state does not provide farmers and agricultural advisors with enough accurate information to make sufficiently accurate crop protection decisions.

Eventually, when the solutions designed and implemented in the ScaleAgData project are implemented, the process will be based on both cyclic and occasional field observations by specialists and improved mathematical models operating on interpolated meteorological data. The indications of the algorithms will be available to both farmers and field observers, who will be able to make better decisions about occasional observations based on which farmers will receive even more precise information about the pests' occurrences.

3.3.4.3 Technologies Used

Our solutions are mainly based on open-source technologies and a large part of the solutions developed in other projects are carried out by the leader and partners.

Weather data comes from meteorological stations that have been installed in the eDWIN project. We have a total of more than 550 of them throughout Poland. Data from the stations is sent directly or indirectly to the PSNC servers and is stored in database InfluxDb. The weather data are used in mathematical models that determine pest risk. The number of models is increasing all the time. The models are validated by the plant protection institute. Most of the disease models are implemented in PHP and are offered internally in the eDWIN ecosystem through an API, while those from the IPM Decisions project are provided through an external API.

Observational data are collected by a dedicated mobile application on Android and their further handling in the form of, among other things, reporting is implemented through an API written in JavaScript. The dictionary data for the observation data collection application is stored in MySQL databases and is passed on via an API written in Laravel.

NDVI data will also play a large role in the future process, the calculation of which is made possible through collaboration with the Agrobank project.

The interpolator is based on an open-source library called SciPy. <https://docs.scipy.org/doc/scipy/reference/generated/scipy.interpolate.griddata.html>

The linear method has been chosen because of lack of the data to use the cubic method. The process takes into account all the available data and is independent of temperature and humidity.

3.3.4.4 Deployment Information - Timeline

The complete solution must be ready for mid-March 2025 due to the field observation season taking off. The launch is planned for March.

3.3.4.5 Integration with Existing Systems

Our solution makes use of existing solutions at every stage. The platform into which we integrate the solutions developed at ScaleAgData is eDWIN. As part of the platform, farmers in Poland receive access to, among other things, the Virtual Farm application, through which they can maintain field charts and plan their work.

Agricultural advisors, on the other hand, have access to 2 systems within the platform: eODR (the back office for the Virtual Farm, where advisors can interact with the farmer) and the Field Application, through which specialist advisors periodically report their field observations of agrophage occurrences.

Our solution for improving and scaling early detection of pests in fields will be integrated mainly into these 3 systems.

3.3.4.6 Deployment Locations

All research locations were placed in the Wielkopolskie Voivodship. The locations are fields where field observations are or will be made and where meteorological stations are installed or in the near vicinity (maximum 3 km).



Figure 9: Location of fields of interest for RIL2c

3.3.4.7 Primary End-users

The main audiences are farmers using the Virtual Farm application, an application offered by the free

nationwide eDWIN platform. These are very diverse audiences in terms of size and technical sophistication, so the service offered under RIL needs to be universal.

3.3.4.8 Target Groups

Additional target groups are primarily agricultural advisors working in provincial agricultural advisory centers. They are already beneficiaries of the possibilities offered by the eDWIN platform and are involved through this platform, inter alia, in the interactive advising of farmers. One of their tasks is to carry out field observations based on which farmers receive risk notifications. We want this target group to become even better informed about possible pest occurrences through ScaleAgData and thus more effective in their work of making recommendations to farmers.

In addition to farm advisors, policy makers will also benefit from RIL2c, as they will be able to better plan national pest observation activities and thus more effectively manage the budget allocated to these activities.

3.3.4.9 User Needs and Expectations

Advisors, despite being confident that there is no threat in a field, must go to that field and document the absence of a pest in the field. The solution that RIL2c offers will allow them to act more efficiently, i.e. one report for a field will determine the absence of a threat for all pests that could occur in that field.

In addition, to make the advisors' work more measurable for the farmer, RIL will develop the possibility of reporting occasional threats, i.e. threats that the advisors observe not in the field designated by them earlier, but in another field, where the algorithm developed in RIL has indicated to them a high risk of occurrence. Their task will then be to confirm that this risk actually exists. Farmers and other advisors in the area will then receive notification that the risk is present.

3.3.4.10 . Evaluation Objectives

The solution offered in RIL2c is primarily intended to bring a tangible benefit to the farmer, who will be able to better plan and carry out crop protection tasks. This will translate into his better yield and savings. However, these 2 aspects will be difficult for us to measure, but we will focus on the percentage indicators.

There should be more recommendations than before, while the number of treatments should decrease successively (over many years). Farmers will gain confidence in the recommendations made by advisors and will not use plant protection products more than necessary.

In the short term, therefore, there should be a percentage increase in recommendations and in the long term a percentage decrease in the number of plant protection treatments carried out. The benefits will also be felt by advisers, who will have to travel much shorter distances to achieve good pest detection rates. This in turn means savings on fuel and reduced emissions.

3.3.4.11 Evaluation Approach

RIL2c will compare the current figures with those that will be achieved once the solution developed at RIL is implemented. In this way, we will be able to continuously monitor the percentage improvement in performance.

Our evaluation integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions.

3.3.4.12 Key Performance Indicators (KPIs)

- Better crop management by farmers (more efficient pesticides control; KPI: number of recommendations (increased in comparison to last years)
- Avoidance of unnecessary visit for inspections; KPI: less travel distance
- Increased commitment of advisors; KPI: percentage of advisors using implemented tool
- Better quality on product; KPI: yield increase

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Increase in Advisors' Interest in Using the Data Product

The number of advisors using the system in the Wielkopolska region is expected to increase by 30% from the current 34 advisors. Currently, no advisors are using the data product, but with the introduction of new features, more advisors are expected to engage. This will improve their efficiency and decision-making, leading to more targeted alerts and recommendations for farmers, ultimately enhancing advisory services and agricultural productivity.

KPI 2: Decrease in Pesticide Use per Hectare

A low influence is estimated, with a 5-10% reduction in pesticide use per hectare. The current goal is to measure the difference in pesticide application before and after implementing the decision support system (DSS). The system will provide farmers with data-driven recommendations, enabling better decisions on plant protection. While this will reduce pesticide use and environmental pollution, the expected impact remains limited at this stage.

KPI 3: Reduction in the Number of Treatments from Field Reports

The number of pesticide treatments is targeted to decrease by 20% from the current 144,217 treatments recorded in 2024. The decision support system (DSS) will provide more accurate pest occurrence probability calculations, allowing farmers to optimize treatment schedules. This reduction in unnecessary treatments will lower costs, reduce environmental impact, and improve the sustainability of farming practices.

KPI 4: Decrease in Crop Reduction / Increase in Yield per Hectare

A low influence is estimated, with a 5% decrease in crop reduction. The effective use of plant protection products, guided by the DSS system, should improve crop management and reduce losses. Farmers will receive more targeted information, leading to better crop health and potentially higher yields.

However, the overall impact is expected to remain modest in the short term.

KPI 5: Increase in Pest Detection Effectiveness

The effectiveness of pest detection is expected to increase by 10-20% due to a higher number of observations. Currently, the detection rate includes 442 pest cases and 394 disease cases on crops such as wheat, sugar beet, and corn. With more observation points, the system will improve early pest identification, allowing for better-targeted interventions, reducing crop losses, and increasing the efficiency of advisors.

KPI 6: Creation of Datasets for Further Scientific Research The number of reports generated for scientific research is expected to increase, expanding the available datasets for further study. Currently, 6,000 reports per year are collected on crops like wheat and corn. The increased data collection will improve research opportunities, enhance the detection of pests, and support advancements in agricultural research, leading to better pest management strategies and precision agriculture solutions.

KPI 7: Increase in Alerts Generated from Observations and Numerical Models

The number of alerts issued to farmers is targeted to increase by 20%. Currently, there are 13,775 alerts generated from models and 202,567 alerts from reports. With improved pest occurrence probability calculations, the decision support system will generate more accurate and timely alerts, enhancing farmers' ability to manage crops efficiently while minimizing unnecessary pesticide applications.

KPI 8: Decrease in Travel Time for Inspection Activities

Travel distances for field inspections are targeted to decrease by 20% from the current 31,096 km. By optimizing observation point inspections using the decision support system, advisors will be able to reduce travel time and improve efficiency. This will lead to cost savings, better resource allocation, and more effective monitoring of agricultural conditions.

Early pest detection algorithms can help improve agricultural decision-making by enhancing advisory services and enabling more targeted interventions. More effective pest monitoring and reduced pesticide use could contribute to lowering environmental pollution and improving resource efficiency, aligning with **SDG 6 (Clean Water)** and **SDG 12 (Sustainable Consumption)**. Optimizing crop protection strategies may support better crop health and reduce losses, contributing to more **sustainable farming practices**. Expanding datasets for scientific research has the potential to **advance precision agriculture and pest management solutions**. Additionally, increasing the accuracy of alerts and optimizing inspection travel could enhance efficiency, supporting the **EU Green Deal's goals for sustainable farming and climate resilience**.

3.3.4.13 Foreseen Risks

- model for interpolating meteorological data is insufficient. This, in turn, may lead to the refinement of the notification system for advisors on potential sites with pest occurrences being based on one less source than originally envisaged, and thus the refinement being less effective than anticipated.

3.3.4.14 Feedback from participants

The initial evaluation of the added value, usability, usefulness took place during the interactive session held as part of the organized demonstration on February 10. Feedback was collected from external

stakeholders representing various target groups. The key questions addressed and the corresponding responses are as follows:

- The analysis of target groups represented in the study highlights a diverse range of stakeholders involved in agricultural innovation. The largest share, 38%, comes from the scientific community and academia, demonstrating strong interest from research institutions. Farmers, advisors, and their associations make up 35%, indicating practical engagement from those directly involved in agriculture. SMEs, agribusinesses, and agritech companies account for 31%, showing significant industry participation. Other groups, such as technology providers (12%) and the insurance sector (8%), also play a role, while policymakers (4%) and general public consumers (4%) are less represented. European institutions do not appear in the responses.
- The extent to which pesticide sensors enhance the monitoring of the Common Agricultural Policy (CAP) is rated at 4.1 out of 5. This indicates that, while the technology is seen as beneficial, further optimization and testing might be needed to achieve full effectiveness.
- The tools for agri-environmental monitoring, decision support systems, and early pest detection are expected to benefit different groups. It is considered most beneficial for farmers (100%), followed by agricultural consultants (67%) and policymakers (67%). Researchers (33%), environmental agencies (17%), and other stakeholders (17%) also see potential value. These insights highlight the broad applicability of these tools across the agricultural and policy landscape.
- The tools presented are perceived as most useful for monitoring agricultural policies and sustainability, as well as supporting farmers with data-driven decisions, with both purposes receiving 100% agreement. Other significant benefits include reducing the environmental impact of farming (50%) and improving food security and crop productivity (33%).
- Beyond the primary target groups, additional beneficiaries of these tools include local governments (100%), food industry and supply chain managers (83%), and NGOs advocating for sustainable farming (67%). Climate change researchers (17%) were also mentioned, suggesting that the technology has relevance across multiple sectors.
- The biggest challenges in using such services revolve around data privacy and security concerns (67%), followed by limited compatibility with existing systems (50%). Other concerns include the complexity of the system, high costs, and the uncertainty of how insights can be effectively applied.
- Improvements that could enhance the practicality and adoption of these tools include better integration with existing farm management systems (60%), clearer data privacy policies (60%), and stronger collaboration with policymakers and farmers (40%). Other suggested improvements include increased training and customization for different users.
- The potential benefits these services could provide include helping farmers manage crops more efficiently (100%), improving crop yields (80%), and reducing overuse of pesticides and fertilizers (40%). Other key advantages include reducing costs for farmers, and providing early warnings for environmental risks.

Furthermore extra feedback will be collected on 26 February when we meet internally.

3.3.4.15 Future Developments Planned Improvements for 2nd Iteration

The planned updates are primarily to enable observers to carry out an occasional observation this season, i.e. one which, thanks to the indications of sites by models refined within RIL, will allow advisors to carry out additional field vetting with a much higher probability of success. This implementation must happen by the second half of March.

In addition, an analysis of the effectiveness of the data interpolator is planned. If its effectiveness is found to be higher, it will be necessary to implement it in the production of mathematical models.

3.3.4.16 Scalability and Replication

The developed solution will be tested in the Wielkopolska region. However, the final implementation should be scaled up for all other regions of Poland

3.3.4.17 Supporting Materials - Images/Diagrams

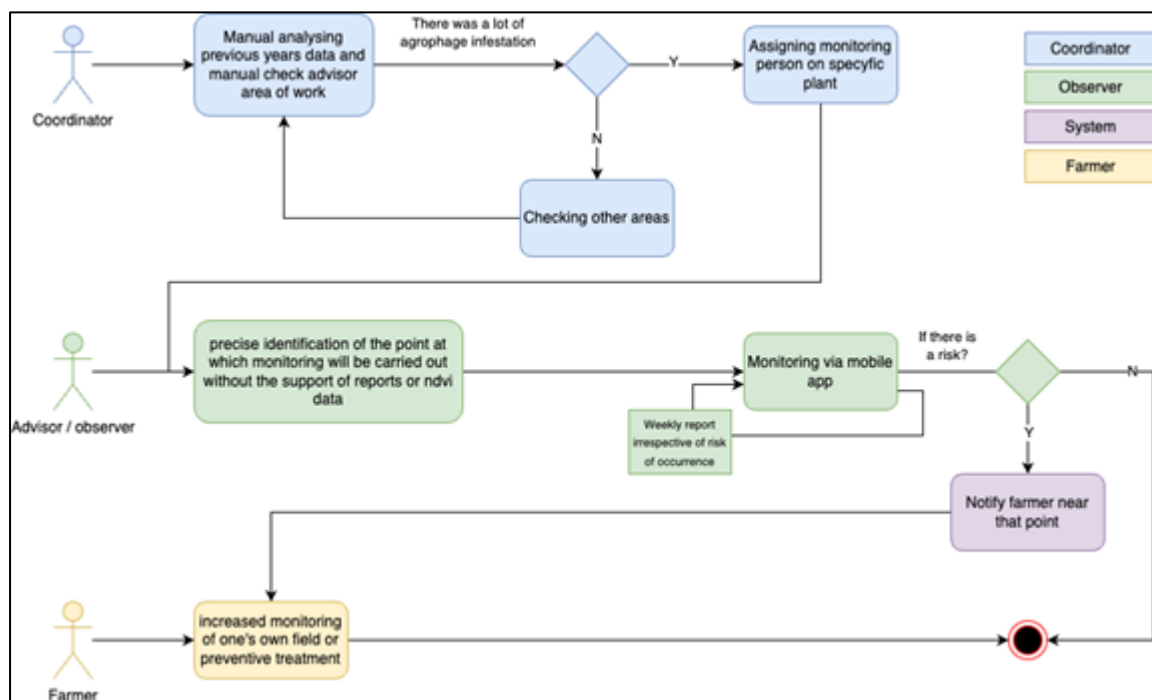


Figure 10: Diagram of process available to the stakeholders before the implementation in ScaleAg-Data began.

3.3.4.18 Relevant Documentation

There are no further relevant documents.

3.3.5 RIL3.1 – Improved potato tare estimator

3.3.5.1 Demonstrator Overview

Thematic focus: Yield estimation/improved quality.

Main Objective of the demonstrator: The demonstrator will show the concept of image-based estimation of tare (i.e. soil harvested along with the potatoes) employing RGB images taken from the transporter belt installed on the potato harvester. In addition, the estimator will, based on soil properties (e.g. soil type, moisture content), estimate the tare.

3.3.5.2 General Description

The purpose of the demonstrator is to show which data are necessary and the steps involved to calculate the potato tare based on image analysis and/or soil properties. The model will be calibrated for two soil types (sandy and sandy loam), so it is not yet universally applicable for all soil types. Further validation will need to determine whether soil-specific calibration is necessary, and/or whether soil moisture estimates based on EO data or in-field measurements are necessary to improve the tare estimation.

3.3.5.3 End user application

The tare estimation model is developed in Python and requires raw RGB images as input. When RGB images of the potatoes on the harvester are available, the model will return an overall tare estimate. If coordinates are available of the RGB images, a location-specific estimate of tare could be returned as output.

3.3.5.4 Technologies Used

- **Imaging and Vision Systems:** Cameras on the harvester
- **Weight Sensors:** Accurately measure gross weight, enabling tare calculation by subtracting potato weight.
- **Moisture Sensors:** Detect soil moisture levels, influencing tare composition and ensuring precise tare weight adjustments.
- **Earth Observation (EO) Data:** Satellite-based EO data, including moisture estimation can be used for large-scale agricultural monitoring.
- **Data Aggregation and Fusion:** Advanced techniques for data aggregation, assimilation, and fusion are applied to combine diverse data sources, including IoT sensors, EO data, and open European datasets. This enables comprehensive analysis and reporting of agricultural performance and policy impact.

- **Machine learning and image recognition software** identify and quantify non-potato materials like soil, rocks, and plant debris. Machine learning models trained to distinguish potatoes from tare materials in real-time.

3.3.5.5 Deployment Information - Timeline

The model is still in the first stages. Parameters and thresholds still need to be optimized, which will be done in the next two months (March 2025). Data are available for the calibration of two soil types (sandy-loam and sandy). In the next growing season (August-October 2025), validation experiments need to be performed, whereby post-harvest potato (with soil) samples need to be collected and compared to the tare estimation of the processed RGB images. This will need to be done in fields with different soil types: (i) sand and loamy-sand for a true validation and to test whether a soil moisture estimate should be included in the model, and (ii) other types of soil such as loam to test whether the model can be applied without a soil-specific calibration.

3.3.5.6 Integration with Existing Systems

The model is not in the development stage yet for it to be integrated with existing systems.

The goal is to in future embedded the demonstrator into harvesters or sorting equipment. Model outputs can be used to adjust machine settings dynamically to separate potatoes from debris more efficiently. The demonstrator's tare weight estimations can be linked to logistics software to optimize truckloads and ensure accurate shipping documentation.

3.3.5.7 Deployment Locations

The data for the model calibration were gathered on two potato fields in Flanders, Belgium.

Field 1:

- (10/9/2024) Izenbergestraat 175, 8690 Alveringem
- sandy-loam soil

Field 2:

- (16/10/2024) Heide 6, 2470 Retie
- sandy soil



Figure 11: Locations of the two calibration experiments (field 1 in the West, field 2 in the East).

3.3.5.8 Primary End-users

The need for RGB images from the transporter belt of harvesters limits the potential end-users. Any farmer using harvesters equipped with a camera can use the model. Depending on the privacy policy, the data could be used by research institutions and policymakers.

The **primary end-users** are the **farmers, contractors, traders, and the processing industry**

- **Farmers:** Benefit from improved yield estimation, reduced tare weight, and better pricing negotiations.
- **Contractors:** Use the demonstrator to optimize harvesting and reduce soil loss during collection.
- **Traders / Processing industry:** Optimize vehicle loads to comply with weight restrictions and reduce transportation costs. Improve planning for delivery schedules based on accurate tare data. Enhance sorting efficiency and product quality control.

3.3.5.9 Target Groups

The target groups are **Research Institutions, Policy Makers, Environmental Agencies and Agricultural Consultants**

- **Research Institutions:** The processed data could also be used by research institutions to map more easily and efficiently the soil loss due to harvest over a large area, comprising different types of fields and circumstances.
- **Policy Makers:** Use data insights to inform policies on sustainable farming and soil conservation. Monitor the effectiveness of regulations on soil management and agricultural sustainability.
- **Environmental Agencies:** Monitor soil loss and other environmental impacts of harvesting.
- **Agricultural Consultants:** Use the demonstrator to advise farmers on best practices for soil management and harvesting techniques

3.3.5.10 User Needs and Expectations

The model gives an objective estimate of the tare. This eliminates the need to subjectively estimate it based on visual observation, reducing the risk of an unfair price setting.

Needs and Expectations:

- Accurate estimation of net potato yield for fair pricing.
- Reduced soil loss and environmental impact during harvesting.
- Insights to optimize harvesting equipment and techniques.

Challenges:

- High variability in soil composition and moisture complicates tare estimation.
- Inefficient harvesting practices lead to increased tare and soil loss.

Solutions Provided by the Demonstrator:

- Real-time tare estimation improves yield calculations and pricing transparency.
- Provides data to fine-tune machinery settings, reducing the amount of non-potato materials collected.

Enables monitoring of soil loss trends, supporting sustainable farming practices.

3.3.5.11 Evaluation Objectives

The purpose of the evaluation is to assess the effectiveness and practicality of the potato tare estimation tool, which utilizes image analysis to determine the proportion of tare (soil, debris, and defects) in harvested potatoes. The evaluation will focus on several key aspects:

- **Performance:** Assessing the accuracy of tare estimation compared to manual methods and industry standards.
- **Usefulness:** Evaluating how well the tool supports decision-making in potato processing and quality control.
- **Usability:** Measuring ease of use, intuitiveness, and efficiency for end users, such as farmers and processing facility operators.
- **Impact:** Determining the tool's contribution to improving efficiency, reducing waste, and enhancing the consistency of tare estimation.
- **User Satisfaction:** Gathering feedback on user experience, including confidence in results and overall satisfaction with the tool.
- **Alignment with Goals:** Ensuring that the tool meets its intended purpose, aligns with industry needs, and integrates effectively into existing workflows.

The evaluation process will involve testing the tool in real-world conditions, comparing its outputs with manual assessments, and collecting user feedback to refine its functionality and usability.

3.3.5.12 Evaluation Approach

The evaluation approach integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by

lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions.

A first demonstration event was organized on 10 February 2025. The Yield Lab partners invited a group of potential users / stakeholders, presented the products and services that are being developed and collected feedback from the participants on how the products could be further improved, as well as on the usefulness and usability of the envisaged services.

A second demonstration event will be organized towards the end of the second iteration of ScaleAg-Data.

In the meantime, the model parameters will be optimized by minimizing the difference between the image-based estimation of tare and the measured amount of tare. A differentiation between soil adhering to the potatoes and soil clods need to be made, as the latter is typically more variable than the first. The adhering soil will be estimated by the relative amount of 'soil-pixels' to 'potato-pixels'. The relation between this pixel-based tare and the true tare (relative weight of adhered soil to weight of potatoes) is not linear and will be estimated based on 13 samples (field 1), for which separate data of adhered soil and soil clods are available. The soil clod weight will be estimated based on the size (based on 13 samples of field 1 and 10 samples of field 2). Once the theoretical tare is calculated, the model can be evaluated, and an error rate can be determined.

3.3.5.13 Key Performance Indicators (KPIs)

While it is too early to assess the actual impact, further testing on different fields and soil types after additional data collection in the summer of 2025 will provide a clearer understanding of its effectiveness. For insights into the relevant KPI and the potential contributions to wider impacts, please refer to Section 3.3.6.1.3.

3.3.5.14 Initial Results/Feedback collected

The first demonstration event showed that there was interest in a visualisation of the results. I.e. an interactive map of the field, where you can click on several spots and view the images of the potatoes from that spot in the field together with the estimated tare.

3.3.5.15 Identified Challenges

It is challenging and labour intensive to obtain high-quality data to train and calibrate the model. Only two fields with two different soil types were included in this first iteration. Due to practical limitations, on field 2 physical potato-soil samples do not fully match the RGB images, reducing quality of the

training dataset. This will also reduce the capacity to test whether it is necessary to calibrate the model for different soil types and/or different soil moisture levels.

3.3.5.16 Future Developments Planned Improvements for 2nd Iteration

More data need to be gathered to validate the model, and to test whether soil type-specific calibration is necessary. For this general validation, less intensive data collection is needed. After harvesting fields (where the harvest was performed by harvesters equipped with an RGB camera) sampling potatoes (and soil clods) needs to be done. Soil and potatoes need to be separated and weighed. In addition, potatoes need to be weighed both before and after washing to obtain a general estimate of the tare for that field. These samples can be gathered on a higher number of fields than in the first iteration.

3.3.5.17 Scalability and Replication

Once the accuracy of the model is sufficient and no additional calibration is necessary, the model can be used on any field where a harvester, equipped with an RGB camera, is deployed. Scaling up the image analysis could be interesting to compare with EO data, soil type maps, etc.

3.3.5.18 Supporting Materials - Images/Diagrams

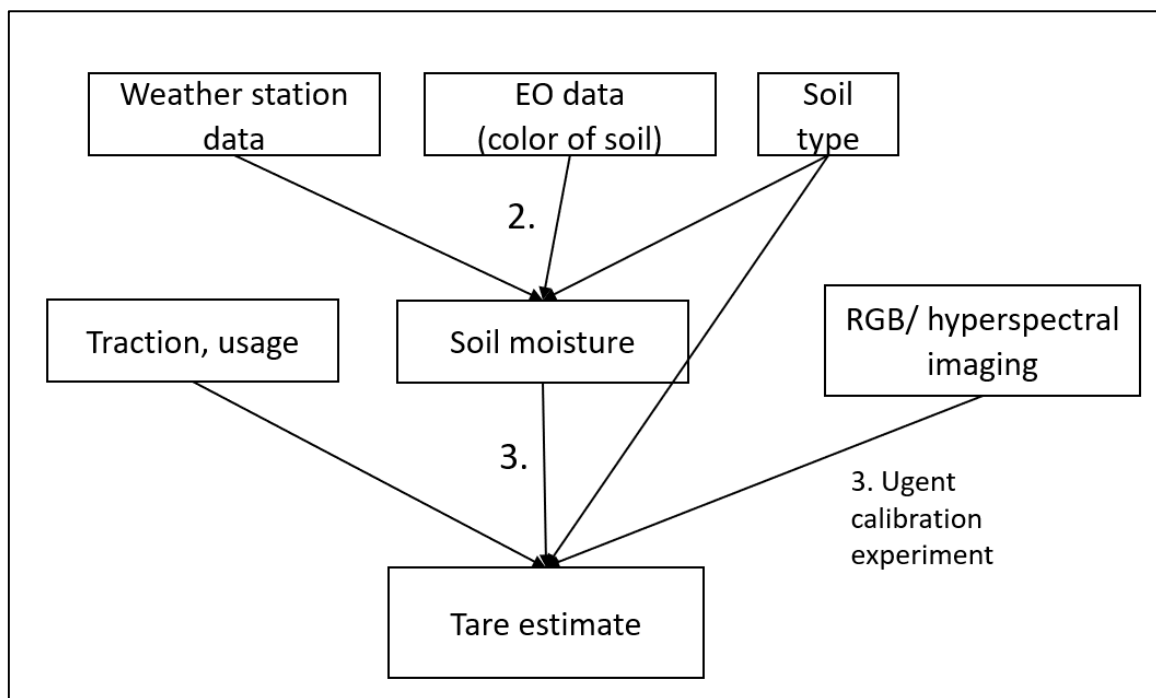


Figure 12: Diagram of the workflow

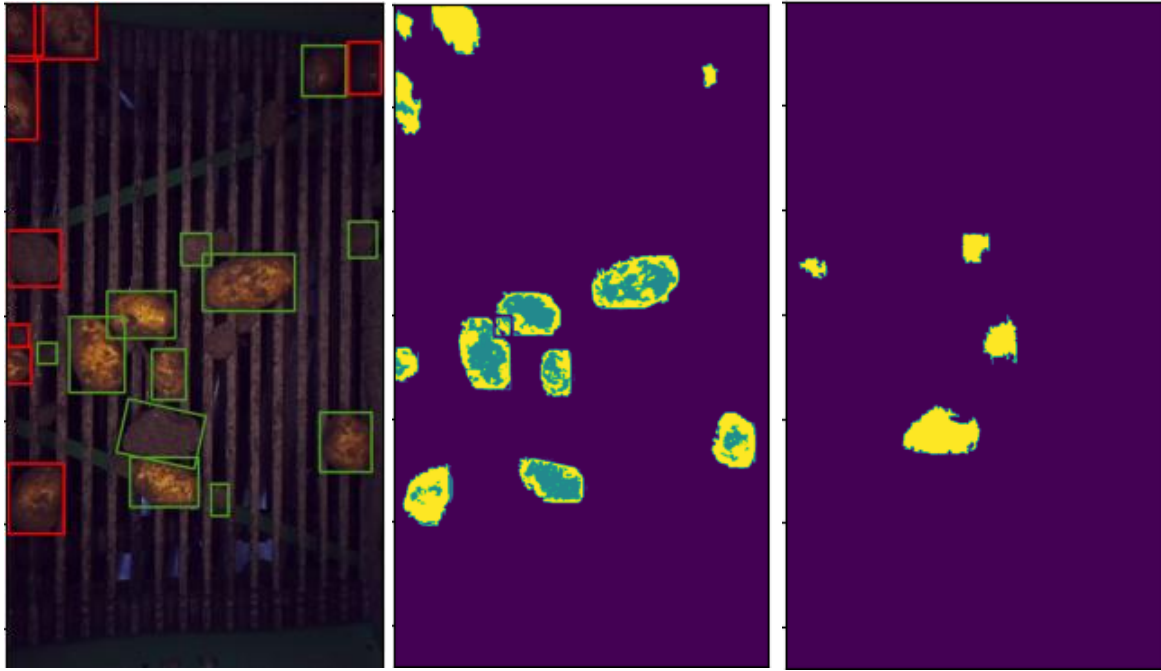


Figure 13: Left harvested potatoes and soil clumps, middle: detected potatoes (soil on potatoes is coloured yellow). Right: detected soil clumps.

3.3.5.19 Relevant Documentation

There are no further relevant documents.

3.3.6 RIL3.2 – Potato and winter wheat yield estimation

3.3.6.1 Demonstrator Overview

Thematic focus: yield estimation / improved quality / informed decision-making

Objective of the demonstrator:

The demonstrator will illustrate how crop yield can be estimated from EO and weather data using two types of models: a machine-learning (ML) model trained with yield data recorded by harvesting machines, and a Digital Twin model trained with in-situ field and sensor data, and management data, if available.

The demonstrator will provide maps, showing for potatoes and wheat the yield variations within the field. This will enable farmers to analyze yield variability within their field and make informed decisions to adjust field practices accordingly. Other target groups are agricultural service providers, machinery producers, insurance companies or seed companies. They could use the yield (variability) maps for improving or extending their current products or services or for research purposes.

Aggregated yield estimates may be of interest to public authorities for crop production monitoring or policy evaluation.

3.3.6.2 General Description

The purpose of the demonstrator is to estimate wheat and potato yield, at sub-field level, from EO and weather data, and farm data (machinery data and management data) if available.

Services for yield estimation are built upon two different types of models.

A machine-learning (ML) model, which was trained with potato yield data recorded by AVR harvesting machines, uses satellite and weather data to generate yield maps and yield variability maps, identifying zones of low, normal and high yields within the field. Based on these model outputs, yield statistics can be generated at various administrative levels.

In the digital twin, real management data, weather data and time series of remote sensing data were combined in single model, which provides estimates of yield and maximum N uptake of winter wheat. The interface to the model was packaged to a web application interfaced using an API.

The products generated by these services can be used by farmers, advisors, agro-industrial players or by public authorities for crop monitoring, forecasting and decision support.

3.3.6.3 End user application

The code to run the yield estimation models will be made available to end-users for integration into their platforms / software.

The **ML model** uses a time series of satellite and weather data to estimate/forecast potato yield at harvest, currently for fields in Belgium and the Netherlands. For a given field, the yield estimation service returns a yield map showing absolute yield estimates at sub-field/pixel level, and a yield variability map, in which the absolute yield per sub-field/pixel is classified according to the deviation with the median yield of the field.

The ML model can be made available for end users through web service APIs. This can include currently available platforms for crop monitoring and Farm Management Information Systems (FMIS). For deployment, requirements are that a model is served in a backend database, and that users can submit field boundaries to the hosting service. Output products (i.e. rasterised yield variability maps and yield estimates) are processed based on inputs and can be downloaded or visualized by the end user.

The **Digital twin** service combines real management data, weather data and up to date remote sensing data to estimate status of the crop and forecast potential yield. The service is provided using an API where the user posts spatial data about fertilizer application, crop leaf area index time series obtained from remote sensing and local weather data. The service returns yield forecast and forecast of potential nitrogen uptake of the crop until the end of the growing season. This information can be used to create task maps for fertilization application tasks. The model is interfaced through REST API with JSON messages. The model and API have been implemented using Kotlin programming language.

The service also provides a calibration endpoint with the aim that the model can be calibrated with on-farm data collection without expert knowledge on crop models and model calibration that respects data ownership. Crop growth is forecasted with a biophysical crop model simplified for precision farming use from APSIM-Wheat model in the ScaleAgData project. The output of the model is constrained to biological and physical limits, i.e. The crop can't grow above maximum photosynthesis potential or exceed N supply.

3.3.6.4 Technologies Used

- Yield sensors on harvesters: potato yield data were obtained from AVR, wheat yield data from CNH
- Machinery data for variable rate and even rate fertilization tasks (fertilization plans) from CNH
- Digital Twin model: set up by LUKE to estimate yield, calibrated with data collected by LUKE, UGent and CNH
- Machine learning: used by VITO to set up a yield estimation model, trained with harvester data from AVR
- Few shot learning as a solution for limited availability of labeled data for model training: developed by VITO and tested for potato yield estimation

3.3.6.5 Deployment Information - Timeline

The models are still in development and need further improvement and validation in other regions, outside Belgium. This will be done during the second iteration phase of ScaleAgData (2025-2026).

3.3.6.6 Integration with Existing Systems

The models are not in the development stage yet to be integrated with existing systems.

The goal for the **ML model**, in the future, is to offer it as a service that can be integrated into FMIS or other software/systems for crop monitoring used by companies (machinery producers, seed breeding companies, insurance companies,...) or by public organizations. The model will also be embedded into WatchITgrow, a platform for crop monitoring, managed by VITO.

Digital Twin – modelling is also planned to work as a service and in future could be integrated for instance with operational FMIS software. Data formats and interfaces for using CNH harvester yield maps and fertilizer application data were implemented in the project and API for interfacing the service was defined. EO data for the model was retrieved from the TerraScope platform.

3.3.6.7 Deployment Locations

For training the potato yield ML model, harvester data collected in Belgium and the Netherlands have been used.

Digital twin modeling has been developed in two regions, one in Southern Finland and one in Belgium. Deployment areas are cultivated fields with approximate sizes around 2...5 hectares.

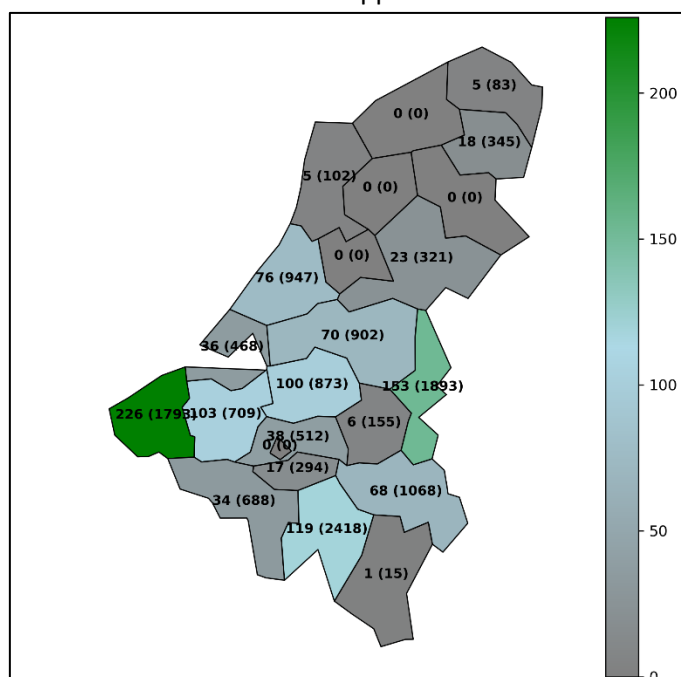


Figure 14: Numbers of fields (and subfields) used for training yield estimation model in the provinces of Belgium/Netherlands

3.3.6.8 Primary End-users

The primary end-users of the demonstrator products include **farmers, advisors or researchers**. Potential customers for the demonstrator service are **agricultural service providers** offering FMIS or

decision-support tools to farmers.

ML based yield maps can be used by farmers, whether or not in collaboration with advisors or researchers, to evaluate the past season, to check if management practices were successful. They can also be used to compare yield variations across years and determine their causes. Recurrent low or high yielding zones may result from differences in soil type or structure, while seasonal variations are more likely caused by weather, diseases, management practices, etc.

After diagnosing the causes of the observed yield variations, the yield maps can be used to help optimize field management.

Digital twin can provide locally calibrated sub-parcel level forecasts on crop N uptake and potential yield with daily time step. This data can support management decisions during growing season. Primary end-users are agricultural farms using variable rate technologies (VRT), as the modeling can be carried out with high spatial resolution. The end users for the decision support system are farmers, however the farmer facing interface needs to be developed. The service is designed so that the model forecasts could be presented in existing FMIS software, however additional integration to such software would be needed. Researchers can be seen as end-users for the presented digital twin framework as well in adapting the system to more crops and integrating other data sources into the model to potentially improve the model accuracy.

3.3.6.9 Target Groups

Besides farmers, the ML derived yield maps will also be useful for **insurance companies** in assessing damage or evaluating the historical performance of their customers' fields. Further, the maps could also be of interest to **machinery producers**, to improve the quality of yield maps from their harvesters, or to input suppliers, such as **seed companies**, to select homogeneous fields for trials or seed multiplication.

Aggregated yield estimates can be useful for **public authorities**, for yield monitoring or policy evaluation.

Most potential pathways for operational deployment for the digital twin are through actors that already provide services to farms or manage the farm data. For instance, **FMIS providers** or **machinery companies** may be interested in providing this model service to their customers. Agricultural software used by the farms varies by country, so the actors providing this could be different.

3.3.6.10 User Needs and Expectations

Needs and expectations of farmers and advisors:

Information for decision-making on how to optimize field management practices for improving yield production while ensuring responsible resource usage:

- Estimate of yield at harvest
- Map with yield variations in ongoing and past season(s), showing high-low yielding zones

Needs and expectations of machinery producers:

Yield sensors installed on harvesters are often prone to inaccuracies, resulting in incomplete or unreliable yield maps. Additionally, when combining data from multiple harvesters or sensors operating on the same field, errors in the yield maps may arise.

Additional yield estimates can be helpful to improve the quality of yield maps from the harvesters, e.g. by

- Filling missing yield measurements
- Correcting outliers in yield measurements
- Aligning yield measurements from multiple harvesters operating on the same field

Needs and expectations of the insurance sector:

Information for damage and risk assessment:

- Estimate of yield (and yield loss) at field level, to support loss adjusters who visit the field
- Early estimate of expected yield (and yield losses) in a region
- Information on past yield losses

Needs and expectations of seed companies, agro researchers:

Information for selection of homogeneous trial fields and evaluation of trial results:

- Map with yield variations in ongoing and past season(s), showing high-low yielding zones and providing information on field heterogeneity
- Yield (variability) maps to assess the performance of existing and new varieties under different conditions

Needs and expectations of policy makers:

Yield estimates / statistics at various geographical scales to

- To forecast yield and food security in the ongoing season
- To monitor yield evolution and impact of policy measures

General need of users and service providers:

- Easy-to-understand and easy-to-use information
- Easily accessible information, integrated in existing platforms/tools for crop monitoring, FMIS

3.3.6.11 Evaluation Objectives

In this stage of product & service development, the focus is on showing the first results, i.e. examples of yield (variability) maps and N uptake maps, as well as the envisaged services to a group of possible users / stakeholders (farmers, agro-business, policy makers, scientists), to determine how the products may be further improved, whether the proposed service is useful for the consulted stakeholders or what is needed to ensure its uptake.

3.3.6.12 Evaluation Approach

The evaluation approach integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by

lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions

A first demonstration event was organized on 10 February 2025. The Yield Lab partners invited a group of potential users / stakeholders, presented the products and services that are being developed and collected feedback from the participants on how the products could be further improved, as well as on the usefulness and usability of the envisaged services.

A second demonstration event will be organized towards the end of the second iteration of ScaleAg-Data.

In the meantime, performance, usefulness and usability of the products (potato yield and yield variability maps) will be assessed in collaboration with the stakeholders (farmers and contractors):

- Product performance will be evaluated for a new set of fields for which we have harvester data (not used for training), inside the initial training area
- Product performance will be evaluated for a new set of fields for which we have harvester data, outside the initial training area
- The usefulness and usability of the products will be assessed by farmers who already use harvester yields maps and by those who do not use any yield maps yet.

Evaluation of the wheat yield estimates: generation of yield estimates for a new set of fields with known yields, inside and outside the training area.

3.3.6.13 Key Performance Indicators (KPIs)

The demonstrator developments contribute to the following KPIs:

KPI.07: Development of improved or new data products that provide information on the agri-environmental conditions, are available to the different stakeholders, both within the RILabs as to other stakeholders and cover the different environmental axes (water, air, soil and living organisms) – in progress, first demonstrators have been presented

KPI.08: The improved data products of RILabs are used to optimize the services to farmers, providing information or a service that is not feasible with the in-situ sensors alone. – this will be demonstrated during the second iteration

KPI.09: The improved data products can be used in a precision farming context outside of the RILabs, where the farmer(s) don't have access to sensor technology. – this will be demonstrated during the second iteration

KPI.010: The improved data products are evaluated by different users (both from within as outside the consortium) on their relevance and useability – during the second iteration

KPI.O11: Number and feedback of the project's co-engagement activities such as workshops, webinars with national or EU policy makers, or with other liaised projects or initiatives such as the "Partnership of Agriculture of Data" – co-design, stakeholder and demonstration events were organized

KPI.I1: number of newly developed Smart Farming solutions. – in progress

KPI.I2: Number of regions where solutions for strengthening capacities for smart farming were tested. – Belgium and Finland

KPI.I3: Number of engaged possible users for all SF related data products. – 9 possible users attended the demonstration event, more possible users attended the stakeholders events

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Number of Advisors or Farmers Interested in Using Yield Maps – A favorable effect has been observed, with 5 participants per event expressing interest in using yield maps for evaluating management practices and diagnosing yield variations. Currently, workshops attract around 20 attendees per event, and through demonstration efforts, more farmers and advisors are engaging with yield maps. This adoption supports better decision-making for climate adaptation and increased agricultural production efficiency.

KPI 2: Decrease in (Chemical) Fertilizer Use

A favorable effect is estimated, with a projected 5% reduction in fertilizer use. This assumes that ScaleAgData's yield and N uptake maps are widely available and used for variable rate fertilization. Farmers will be able to optimize fertilizer application, reducing costs and minimizing environmental pollution in soil and water while improving long-term soil health and productivity.

KPI 3: Creation of Methods and Datasets for Yield Monitoring

The target is to develop two new methods and create two types of demonstration products for five regions and four user types. These datasets and products aim to provide farmers, agricultural service providers, and researchers with tools to improve decision-making, enhance scientific research, and support technological advancements in precision agriculture and yield estimation.

KPI 4: Number of Agricultural Service Providers, Machinery Producers, Insurance Companies, and Public Authorities Interested in Adopting Services

The target is to generate interest from two agricultural service providers, two machinery producers, two insurance companies, and one public authority in adopting ScaleAgData's services. These stakeholders can benefit from access to yield estimation tools, improving efficiency in field trials, crop monitoring, insurance loss assessments, and food security planning while reducing costs associated with independent product development.

The solutions and methods developed in the Yield Management R&I Lab contribute to more sustainable and competitive agriculture through digital technologies. Yield maps and precision monitoring

tools can support better decision-making, helping optimize resource use and improve climate adaptation in alignment with the **European Green Deal** and **Farm to Fork Strategy**. By enabling more precise fertilization strategies, these innovations may help reduce chemical inputs and minimize environmental pollution, contributing to **sustainable soil management**. Additionally, advanced yield monitoring methods can strengthen **agri-environmental monitoring**, providing useful data to track sustainability efforts and inform **EU CAP policies** that encourage eco-friendly farming. These digital solutions may also improve efficiency and reduce resource waste, aligning with **SDG 12 (Responsible Consumption and Production)**. Through data-driven innovation, the lab can support **smart farming and sustainability**, contributing to the resilience of the EU food system and the advancement of sustainable agricultural practices.

3.3.6.14 Identified Challenges

Challenges encountered during the development of the ML model for potato yield estimation:

- Outliers in the harvester yield data
- Lack of information on crop variety and field management practices

Challenges identified during the evaluation of the demonstrator:

- For a cereal modeling service, achieving both good enough accuracy and low enough price per hectare are challenges. Cereals are not high-value crops.

3.3.6.15 Feedback from participants

The following feedback was collected from the stakeholders during the first Demonstration event.

On the **ML model** for potato yield estimation:

- For a farmer, having information about yield variations within the field is more important than having information about absolute yields
- In addition to yield (ton/ha), having information about product quality (size of the tubers) is very important
- Better soil tare estimates will result in improved harvester yield maps (and more accurate model inputs)
- Adding information about potato variety (early vs. late) and field management practices (planting date,...) may help to further increase model accuracy

On the **digital twin**:

- Farms do not want to share their data or give it out. Therefore, presented model calibration that respects the data ownership is important.
- Farms do not necessarily have access to the data even for themselves; images instead of actual data. Anyhow this is slowly changing.
- Implementation of the system to the whole production chain at the farm would be an asset, taking into account which machines are used etc. and making the service work in the chain.
- Identified potential actors such as machinery companies and advisory firms that have services on task maps.
- There could be more interest in the result once there is a concrete product available that

could be demonstrated.

3.3.6.16 Future Developments Planned Improvements for 2nd Iteration

The **ML model** for potato yield estimation will be further improved by the inclusion of improved data input. Currently, effectiveness of the model is reduced due to noise and uncertainty in the raw harvester data. To remedy this, several improvements are envisioned:

- Develop methods among researchers and data providers to provide best practice in cleaning input data, and filtering outliers based on movement of harvester machine and other relevant information.
- Based on available field knowledge and model performance metrics, provide a confidence estimate based on similarity of fields, satellite inputs, and harvest data. This can allow for further model refinement, and the presentation of reliable results.
- Utilise other technology developed through ScaleAgData, including improved soil moisture mapping, and utilizing tare estimation to refine input harvester yield data.
- Where possible, gather additional field management information to provide further model inputs.

Additionally, the model should be made available as an API through FMIS or other web services, allowing end users to submit their agricultural field boundaries in the applicable region, returning a field variability or yield estimate based on the available model and satellite inputs at the time of the request.

The model can also be made available at a field level to provide estimates in cases where farmers do not have access to yield sensors in their harvester (Figure 4). Additionally, when provided a regional list of fields, it is possible to calculate the yield on an upscaled, regional level, providing the basis for regional statistics quickly at the end of the growing season.

The API to the **digital twin** will be developed using standard OpenAPI format and published. Example python code for using the service will be developed. An endpoint for producing N fertilization tasks based on model forecasts will be developed.

3.3.6.17 Scalability and Replication

The **ML model** for potato yield estimation has been trained using yield data from fields in Belgium and the Netherlands, incorporating specific varieties, soil types, etc. and regional conditions. Its applicability in other regions in Europe will be investigated during the second iteration phase.

The model framework is designed to be adaptable, allowing for the training of models to estimate the yield of other crop types as well.

For **digital twin** the modeling framework and models have been developed to the next phase, replication in other regions (Finland, Greece) can be carried out using the model calibration service. The potential for deployment of digital twin in yield lab will be evaluated with the project partners.

3.3.6.18 Supporting Materials - Images/Diagrams

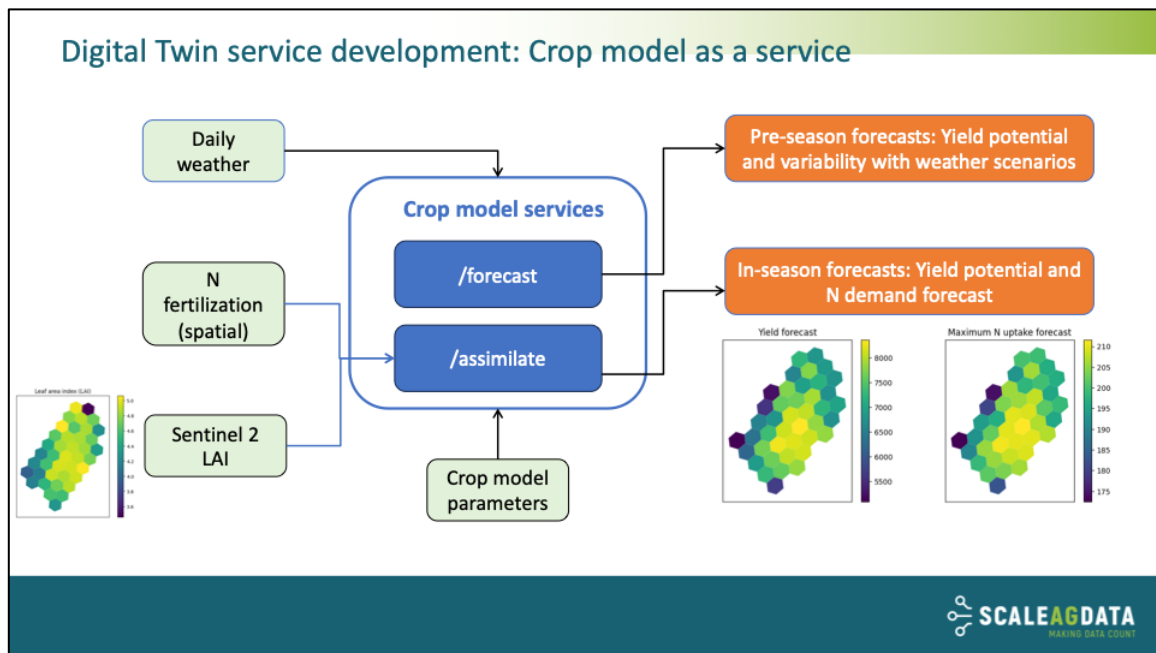


Figure 15: Schematic view of the input data requirements, services and API endpoints of the digital twin model supporting wheat fertilization decisions.

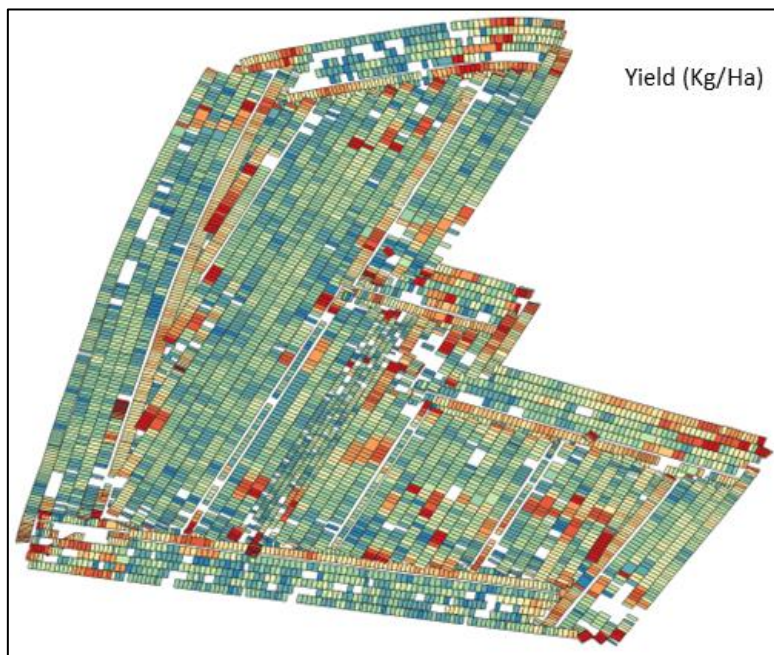


Figure 16: Map showing data recorded by the AVR harvester: estimated potato yield (kg/ha) and changes across field at 1.5 x 3.5m resolution

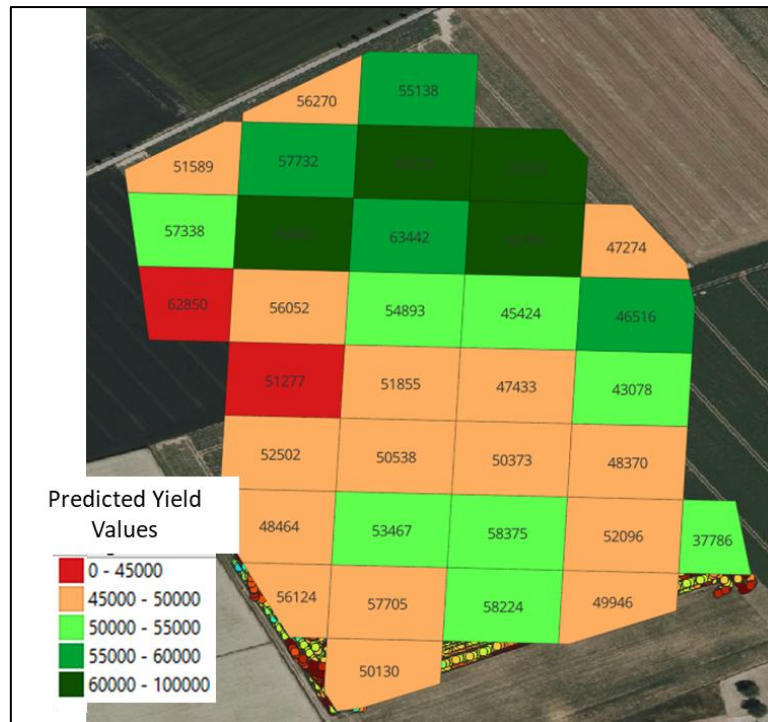


Figure 17: Sample estimation of yield variability (yields are expressed in kg/ha) at 70m x 70m resolution, using model trained with harvester data and PRESTO features.

3.3.7 RIL4.1 – Use of Federated Learning for topsoil Soil Organic Carbon (SOC) model building at regional and national level.

3.3.7.1 Demonstrator Overview

Thematic focus: Privacy-preserving technology (Project Innovation area 6-IA6).

Main Objective: Train ML algorithms on sensitive data; ample soil data available at multiple data owners, however, a lack of willingness to share the data due to data sensitivity, overcome the data privacy issues via Federated Learning (Link to Deployment scenario- DSS3).

3.3.7.2 General Description

The demonstrator will illustrate Federated Learning as an innovative privacy-preserving technology that can be used to train ML algorithms on sensitive data. The RIL will pretrain a Soil Organic Carbon (SOC) model on a European dataset. The pretrained model will then further be trained using regional datasets from Flanders (Belgium) and Greece. Separate ScaleAgData R&I Development Environments and the Flower AI framework will be used to illustrate the client-server approach in which data safely remains at the client without the server obtaining the data. The resulting Federated Learning -trained model will be used to generate regional SOC maps for Flanders and Greece. The Federated Learning trained model will be benchmarked with regional SOC models.

3.3.7.3 Technologies Used

- Copernicus EO
- ScaleAgData R&I Development Environment developed and provided by DEMOS
- Flower AI framework
- QGIS
- Cloud computing technologies

We collaborated with DEMOS as project partner in ScaleAgData.

3.3.7.4 Deployment Information - Timeline

The demonstrator will be TRL4, the demonstrator is planned for the beginning of 2025.

3.3.7.5 Integration with Existing Systems

Limited TRL, so no direct plan to integrate in existing systems, focus on testing new innovative technologies and demonstrating value.

3.3.7.6 Deployment Locations

The demonstrator will cover the regions Flanders (Belgium) and Central Macedonia (Greece)

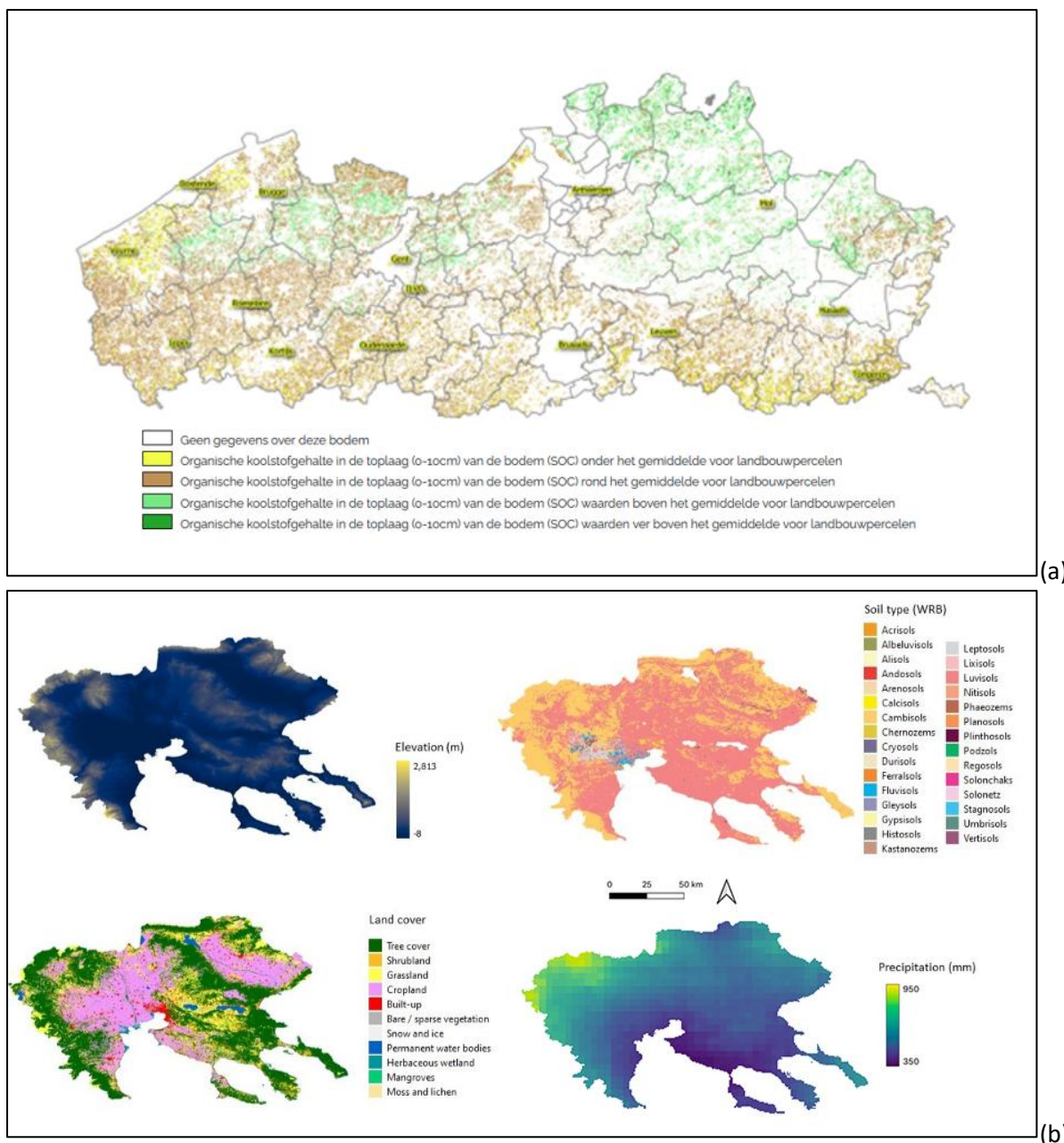


Figure 18: Current SOC maps for Flanders (a) and Central Macedonia (b).

3.3.7.7 Primary End-users

The end users are stakeholders that can benefit from:

- applying the privacy-preserving technology to train ML algorithms with sensitive data: mainly research institutes, agri-tech companies and governmental institutes
- themonitoring insights in the SOC maps: mainly regional/national/EU policymakers, research institutes, farmers, farmers associations, agro-advisors, LightHouses of Living Labs Agronomists of the Competent regional and national administrative units, inspectors, auditors

Describe who the primary users of the demonstrator are, e.g., small-scale farmers, agricultural co-

operatives, policymakers, research institutions, etc.]

3.3.7.8 Target Groups

Target groups for the demonstrator are policy makers, research institutes, agri-tech and farmers; farmers, farmers associations, agro-advisors, researchers, Lighthouses of Living Labs Agronomists of the Competent regional and national administrative units, inspectors, auditors.

3.3.7.9 User Needs and Expectations

The data-providers expect their data are treated with the necessary privacy precautions.

The end-user expects SOC predictions are accurate enough at a detailed geographical scale and reflect real-time temporal dynamics.

3.3.7.10 . Evaluation Objectives

(Describe the purpose of the evaluation, including what aspects of the demonstrator will be assessed (e.g., performance, usefulness, usability, impact, user satisfaction, alignment with goals))

3.3.7.11 Evaluation Approach

The evaluation approach integrates quantitative and qualitative methods to assess the impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like a Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions.

3.3.7.12 Key Performance Indicators (KPIs)

- **KPI.O3 – Data Processing Architecture:** Applied cutting-edge analytics and federated learning to improve the speed, security, and effectiveness of agricultural data processing. This enables faster insights and decision-making for sustainable farming practices (1 target achieved).
- **KPI.O7 – Improvement of Agri-Environmental Data Products:** Developed new data products that provide valuable insights into environmental conditions (water, air, soil, biodiversity). These products support policymakers, researchers, and farmers in making informed decisions to enhance sustainability and productivity (2 targets in progress).
- **KPI.O8 – Enhanced Services for Farmers:** Leveraged improved data products to optimize agricultural services, enabling farmers to make better, data-driven decisions. These innovations support precision farming, reducing resource waste and increasing yield efficiency (1 target in progress).

- **KPI.O9 – Extending Data Use Beyond RILs:** Demonstrated how advanced data products can be utilized in precision farming even by farmers without direct access to sensor technology. This expands the reach of digital farming solutions, promoting wider adoption of sustainable practices (at least 1 demonstration planned).
- **KPI.I1 – Development of Smart Farming Solutions:** A new Smart Farming solution is under development, aimed at improving precision agriculture and optimizing resource use, ultimately enhancing the sector’s economic and environmental performance (1 target in progress).
- **KPI.I2 – Regional Testing of Smart Farming Solutions:** These solutions are being tested in two different regions, ensuring their adaptability to various agricultural contexts and climates (2 targets in progress).
- **KPI.I4 – Soil and Crop Parameter Coverage:** The project is expanding its monitoring capacity by covering additional soil and crop health indicators, crucial for climate-resilient farming (1 target in progress).
- **KPI.I5 – Regional Testing of Monitoring Solutions:** These agri-environmental monitoring solutions are being tested in two different regions, ensuring their effectiveness across diverse agricultural settings (2 targets in progress).
- **KPI.I6 – Engagement of Potential Users for Soil and Crop Data:** Two user groups have been successfully engaged, supporting the wider adoption of advanced soil and crop monitoring tools (2 targets achieved).
- **KPI.I8 – Development of Services for Soil Health Research & Innovation (R&I):** A new data-driven service is under development to contribute to the broader Research & Innovation mission on soil health, supporting sustainable land management (1 target in progress).
- **KPI.I11 – Contribution to Green Deal Actions:** The project actively supports two Green Deal objectives, leveraging environmental observation data to inform policies and sustainable farming practices (2 targets).
- **KPI.I14 – Contribution to Cluster 6 Areas of Intervention:** The project contributes to three intervention areas within Cluster 6, helping to integrate digital and data technologies into sustainable agriculture and environmental management (2 targets).
- **KPI.I15 – Contribution to Cluster 6 Policies & Strategies:** Three key policies and strategies under Cluster 6 are benefiting from the project's data-driven innovations, reinforcing sustainability and competitiveness (3 targets).
- **KPI.I19 – Direct Contribution to SDG Indicators:** The project directly supports three Sustainable Development Goal (SDG) indicators, advancing sustainability through improved environmental and agricultural practices (3 targets).
- **KPI.I20 – Indirect Contribution to SDG Targets:** Indirectly contributes to two SDG targets, reinforcing global efforts in soil health, sustainable farming, and climate adaptation (2 targets).

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: % Increase in Biodiversity in Farmland

A favorable effect is estimated, with an increase in biodiversity due to improved soil monitoring. By providing insights into soil health, farmers can make informed decisions to enhance soil quality and

promote sustainable farming practices. This can contribute to reduce soil degradation and increased biodiversity, though the impact is indirect and challenging to quantify.

KPI 2: % Increase in Number of Datasets/Publications to Support Technology Development

A favorable effect is estimated, with an increase in scientific datasets and publications. The development of SOC models and maps using Federated Learning has already been demonstrated through webinars and published conference papers. This supports scientific research, knowledge transfer, and the creation of similar data products for the agricultural sector, fostering innovation and technological advancements.

KPI 3: Number of Policy Makers/Farmers/Researchers Reached and Informed

A favorable effect is estimated, with an increase in outreach targeting 25 stakeholders. Providing soil health monitoring tools can enhance understanding of carbon stocks and soil conditions, enabling policy makers and farmers to make informed decisions about land management and sustainability. Demonstrated Federated learning encourages data sharing while addressing privacy concerns, making it a valuable approach for agricultural research and decision-making. By fostering collaboration without compromising sensitive data, it can support the development of improved soil models and precision agriculture techniques. However, its long-term adoption for impact on policy and data governance frameworks

KPI 4: % Decrease in Chemical Fertilizer Use

A favorable effect is estimated, with a reduction in chemical fertilizer use due to improved soil health awareness. Monitoring organic carbon levels helps farmers optimize fertilization strategies, reducing costs and environmental impact. Although the influence is indirect and difficult to measure, increased knowledge of sustainable practices may encourage a shift towards lower fertilizer dependency.

KPI 5: % Increase in Soil Organic Matter

A favorable effect is estimated, with an increase in soil organic matter driven by improved soil health monitoring. Informing farmers about SOC levels encourages better soil management practices, reducing soil degradation and emissions. While the impact is indirect and depends on farmer adoption, greater awareness of organic carbon dynamics and monitoring SOC for of their field can contribute to long-term soil sustainability.

KPI 6: % Increase in the Use of Environmentally Friendly Agricultural Practices

A favorable effect is estimated, with an increase in sustainable practices such as no-till farming, agroforestry, and crop rotation. Providing farmers with detailed soil data allows them to implement strategies that improve soil quality and reduce environmental pollution. However, the impact is indirect and depends on the willingness of farmers to adopt new methods.

The **solutions and methodologies developed by the Soil Health Lab** are expected to contribute to **Smart Farming & Agri-Environmental Monitoring**, supporting the **EU Green Deal Goals** by enhancing soil health, biodiversity, and sustainable farming practices. These efforts align with the **Farm to Fork Strategy** and **CAP policies**, helping farmers adopt better land management and resource-efficient practices. By improving soil monitoring, reducing chemical fertilizer use, and promoting environmentally friendly agricultural methods, these approaches may support **SDG 2 (End Hunger)** through sustainable agriculture, **SDG 6 (Clean Water & Sanitation)** by reducing environmental impact, and **SDG**

12 (Responsible Consumption & Production) by optimizing resource use. Additionally, addressing privacy concerns, supports Smart Farming & Agri-Environmental Monitoring by enabling secure data sharing for improved soil models and precision agriculture. It aligns with the EU **Green Deal, Farm to Fork Strategy, and CAP policies**, contributing to **SDG 2 (End Hunger), SDG 12 (Responsible Consumption & Production)**. By fostering collaboration while protecting privacy, it strengthens agricultural research, policy development, and sustainable farming practices.

3.3.7.13 Foreseen Risks

- Finding sufficient soil data
- Developing connections between separate ScaleAgData R&I Development Environments for mutual communication and exchange of information during Federated Learning approach

3.3.7.14 Feedback from participants

The initial evaluation of the added value, usability, usefulness took place during the interactive session held as part of the organized demonstration on February 10. Feedback was collected from external stakeholders representing various target groups (see Annex3). A total of 27 external stakeholders were reached, with varying levels of participation across different questions. The key questions addressed and the corresponding responses are as follows:

- Participants were asked which target group they represent, and the majority (62%) identified as part of the scientific community and academia. Farmers, agribusiness professionals, policy-makers, and technology providers each made up 10% of the respondents, while European institutions accounted for 5%. The insurance sector and general public consumers were not represented. This distribution suggests strong engagement from researchers but limited participation from policymakers and end-users.
- When asked about their familiarity with federated learning before the demonstration, respondents rated their knowledge at an average of 28% on a scale of 0 to 100, indicating that most had little prior understanding of the concept. This highlights the need for further education and awareness on federated learning within the target audience.
- Concerns about AI-driven soil analysis in agriculture varied, with the primary issue for 67% of respondents being the accuracy of AI models. Other significant concerns included data ownership and control (42%), the complexity of technology (38%), data privacy (29%), and implementation costs (13%). These findings suggest that while AI offers potential benefits, adoption is hindered by trust, accessibility, and cost-related challenges.
- Regarding whether the federated learning approach addresses privacy concerns about sharing sensitive data, 27% of participants felt it fully addressed their concerns, while 58% had some reservations, and 15% required further assurances. This indicates that federated learning is seen as a step in the right direction, but additional transparency and security measures are needed to build confidence.
- Participants were also asked about potential privacy risks they see in federated learning. The most cited risk (60%) was the possibility of biased models due to limited data diversity. Trust issues with AI providers or data handlers were also a major concern (56%), followed by a lack of awareness about how updates are shared (44%) and model inversion attacks (24%). No participants considered federated learning to be fully privacy-safe, showing that privacy remains a key issue.

- To increase confidence in the privacy and security of federated learning, participants identified transparency reports on how models are trained as the most important measure (52%). Other significant factors included clear opt-in/opt-out policies for data contributors (25%), independent audits (18%), strong encryption of model updates (11%), and regulatory oversight (11%). These results emphasize the importance of accountability and user control in federated learning.
- When discussing challenges in implementing federated learning for soil analysis, 39% of participants cited a lack of technical expertise and the need for training and support as the biggest barrier. Other challenges included a lack of trust in AI models (30%), technical infrastructure limitations (20%), and cost and regulatory compliance issues (9% each). These findings highlight the need for capacity building and better infrastructure for successful adoption.
- Participants were asked what benefits would motivate them to contribute data, and the top responses were access to better AI models for free and research collaboration opportunities, each cited by 65%. Improved farm productivity was also a strong motivator (52%), while financial compensation was less important (17%). Only 4% selected "Other." These responses suggest that data-sharing incentives should focus on collaboration and performance-based benefits rather than monetary compensation.
- To assess whether SOC maps are helpful in addressing agricultural, scientific, or policy needs, participants provided mixed feedback. While 39% found them very helpful, 48% considered them somewhat helpful but in need of improvements, and 13% did not find them relevant. This suggests that while SOC maps provide value, further enhancements are necessary for broader usability.
- When asked what additional information or improvements would make SOC maps more valuable for their work, respondents highlighted the need for additional soil health indicators (57%) and integration with existing farm management software (57%) as top priorities. Other suggested improvements included higher resolution data (35%), real-time updates (30%), and easier data visualization and interpretation (26%). These results indicate a strong demand for better integration, accuracy, and usability in SOC maps to maximize their effectiveness.
- The majority of participants (90%) see opportunities for scaling the approach in generating SOC maps to other regions, while 10% do not. This suggests strong confidence in the applicability of the method beyond its current scope, though some concerns about feasibility remain.
- To make SOC maps more valuable for their work, participants highlighted the need for additional soil health indicators (57%) and integration with existing farm management software (57%) as the most important improvements. Other suggested enhancements include higher resolution data (35%), real-time updates (30%), and easier data visualization and interpretation (26%). These results suggest a demand for more precise, integrated, and user-friendly mapping tools.
- When asked whether SOC maps effectively address their agricultural, scientific, or policy needs, 39% of respondents found them very helpful, while 48% believed they are somewhat helpful but require improvements. A smaller group (13%) did not find them relevant to their needs. These results indicate that while SOC maps provide value, further refinements are needed to enhance their usability across different sectors.
- The benefits that would motivate participants to contribute data include access to better AI models for free (65%) and research collaboration opportunities (65%). Improved farm productivity (52%) was also a strong motivator, while financial compensation was less of a priority (17%). Only 4% selected "Other," suggesting that non-monetary incentives such as access to advanced AI tools and collaborative research opportunities are the most effective.

- When discussing the main technical or operational barriers that might limit the scalability or adoption of SOC mapping using federated learning, 90% of respondents pointed to a lack of sufficient local data as the biggest challenge. Other significant barriers include the need for specialized technical expertise (48%), regulatory or data-sharing restrictions (48%), infrastructure limitations such as computing power and internet access (29%), and the high cost of implementation (24%). These findings highlight key areas that require attention for successful large-scale implementation.
- Beyond SOC mapping, participants identified several other agricultural challenges that federated learning could effectively address. The most common areas of interest include yield prediction, nutrient analysis, plant protection, pricing estimation, and monitoring flood damage. Other suggestions involved data privacy, irrigation system optimization, and crop type mapping. These responses suggest that federated learning has the potential to support a wide range of applications in precision agriculture, enhancing both productivity and sustainability.

3.3.7.15 Future Developments Planned Improvements for 2nd Iteration

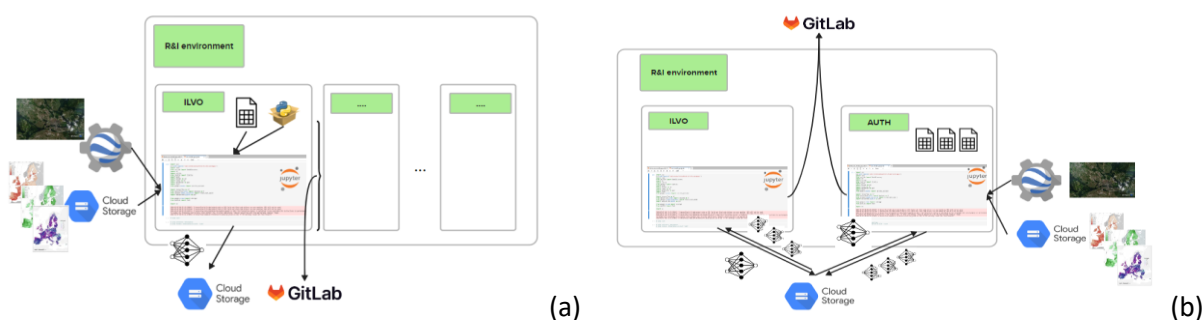
We can further investigate hyperparameter optimization during the training of the neural network model. In addition, we can further investigate the impact of the configuration of the number of clients used and the number of communication rounds between clients and server during the Federated Learning process. We will attempt to find other Flemish SOC datasets to include in the Federated Learning pipeline aiming to prevent bias of the model for Central Macedonia and improve the model accuracy for Flanders.

3.3.7.16 Scalability and Replication

The EU SOC map will be finetuned for regional datasets from Flanders and Greece, the same approach can be applied for other regions if regional datasets are available for Federated Learning training, thus replicating/scaling the demonstrator to other EU regions.

In addition, the Federated Learning approach will be applied on 2 regional datasets, by illustrating the safety of the privacy-preserving technology other public and private data owners can be convinced to provide their data for the training of an improved SOC model.

3.3.7.17 Supporting Materials - Images/Diagrams



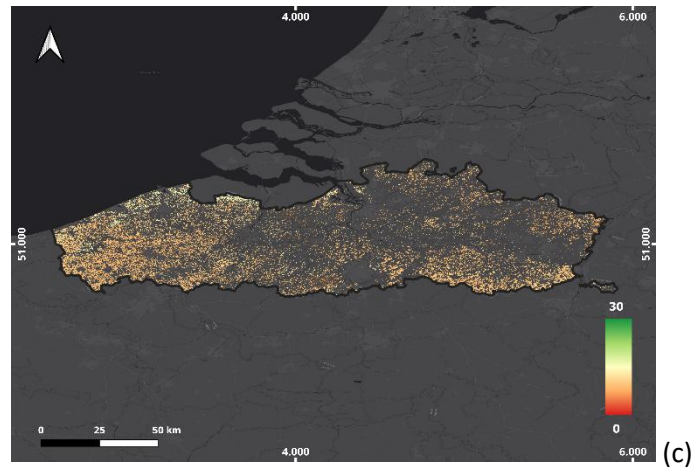


Figure 19: (a) schematic representation of pre-training European model in R&I environment to then be used in next phase with Federated Learning approach, (b) schematic representation of Federated Learning approach in R&I environment with EV-ILVO environment being server and AUTH environment representing multiple clients (c) SOC map for Flanders generated using the resulting Federated Learning model.

3.3.7.18 Relevant Documentation

<https://flower.ai/>

https://github.com/ScaleAGData/scaleagdata_flower_ai

https://github.com/ScaleAGData/federated_ai_soillab

3.3.8 RIL5.1 – Mediterranean grasslands productivity in a changing environment

3.3.8.1 Demonstrator Overview

Thematic focus: Advisory services for farmers on grassland productivity at the field scale under uncertain climate conditions

Main objectives of the demonstrator:

- To improve grassland productivity estimations based on remote sensing
- To validate the grassland productivity models using data collected from farmers of stocking rates, actual supplementary feeding, and livestock needs at the farm scale.
- Design and share a straightforward, user-friendly product to assist farmers in making stocking decisions based on uncertain climate conditions.

3.3.8.2 General Description

Climate largely impacts the production of grassland biomass in the Mediterranean region and, therefore, the stocking capacity of the farms. To rationalize cattle feeding by adapting stocking capacity to current climate uncertainty and the expected increase in drought frequency and intensity, a metric is proposed to inform the farmers about the maximum, average, and minimum biomass their farms produce using historical estimation derived from remote sensing. After a seventeen-year analysis of grassland production and water stress in the area, values per farm for favorable and unfavorable conditions were obtained, and the demonstrator will provide farmers with an estimation of the stocking rate variation (without external supplement). Using these intervals, the stocking rates can be selected depending on the level of intensification desired by the farmer, from fully extensive rangeland production with minimum supplementation (between the low and mean production) to more intensive exploitation with higher supplementation costs. Forecast tools can then be integrated with these metrics to assist in better-informed decisions.

3.3.8.3 Technologies Used

The following technologies were used within the demonstrator:

- **Earth Observation (EO) Data:** Satellite-based EO data and multispectral data are utilized for regional-scale grassland monitoring.
- **In situ data:** In situ regular measurements of grassland leaf area index, fAPAR, aboveground biomass, and field radiometry are performed following a specific protocol that is suitable for the validation of satellite-based products. In addition, continuous measurements of CO₂ and energy exchanges are collected in three locations. They will be used to assess the specific conditions in the fields and their effect on the signals observed by satellite sensors.
- **Machine learning:** In a collaboration between DEIMOS and IFAPA, advanced techniques for gross primary production estimations using machine learning approaches combine multi-sensor EO data (Sentinel-2 MSI, Sentinel-1 SAR).
- **Collaborations:** Key technical providers within ScaleAgData include DEIMOS, offering methodological support relative to developing machine learning models. In collaboration with EURAC in the framework of a research stay, a researcher from IFAPA will test the applicability of the demonstrator 5b1, also in the RIL5 study area in Spain.

3.3.8.4 Deployment Information - Timeline

The demonstrator is currently under development with the following deployment timeline:

First Phase (Early 2025): The initial version of the demonstrator is expected to be ready in the first few months of 2025. This phase will focus on finalizing and validating the grassland productivity product, which will initially be tested on a limited number of farms.

Second Phase (Mid-2025): This phase will involve direct engagement with farmers to collaboratively design the tool for sharing the grassland productivity product. The testing of the demonstrator will also be expanded to include a larger number of farms.

Third Phase (End-2025): In collaboration with the IT services of the cooperative, the service will be integrated into the cooperative's corporate app, allowing the demonstrator to be extended to all associates.

3.3.8.5 Integration with Existing Systems

The demonstrator will be integrated into the end-user applications the cooperative (COVapps) developed as part of their advisory and commercial services for their associates.

3.3.8.6 Deployment Locations

The demonstrator will be deployed initially in several farms (5-10) selected by the cooperative, with the intention of extending the service to all their associates, 2000 cooperative members located in the oak savanna area of two Spanish regions (Andalusia and Extremadura), most of them concentrated in the north of the province of Cordoba.

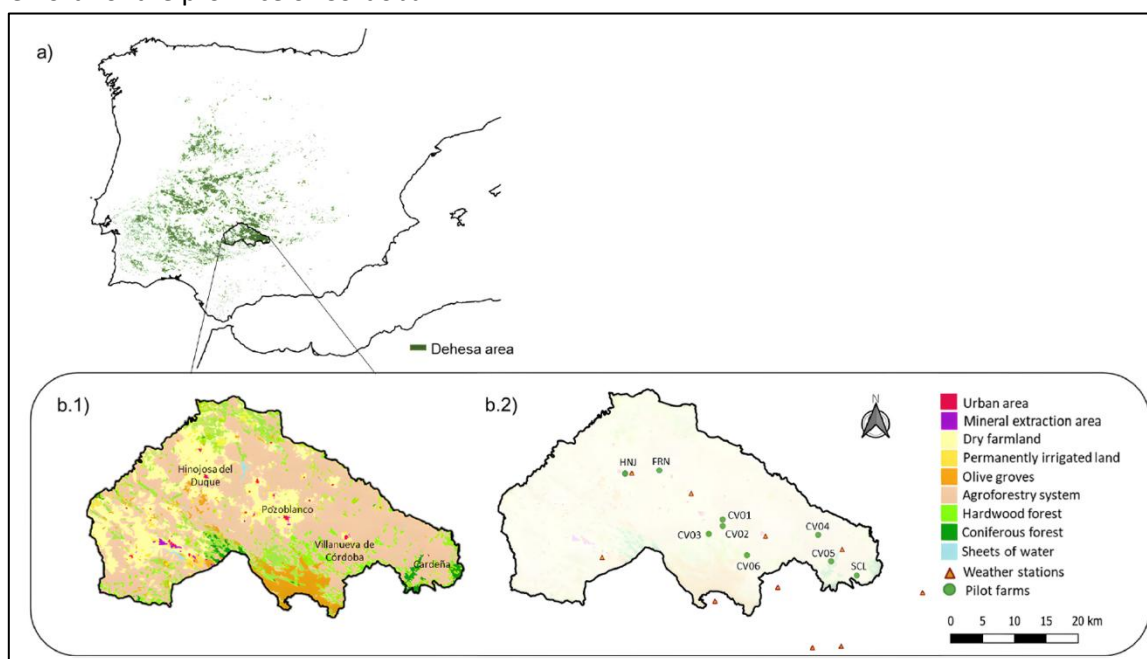


Figure 20: Location and land use map of the region and pilot farms for the demonstrator in Spain.

3.3.8.7 Primary End-users

1. Farmers (Cooperative members): Small and medium-scale farmers in the region of Pedroches, Spain, are key end-users.
2. The technical staff of the cooperative will use the information to improve the advisory services provided to the cooperative members.

3.3.8.8 Target Groups

1. Local authorities: The Department of Agriculture of Andalusia benefits from the introduction of innovative digital technologies in agricultural management.
2. Research Institutions: Agricultural researchers and institutions will be able to use the in-situ data that the demonstrator collects to validate satellite products over oak savanna areas and the methods that the demonstrator proposes for applications in similar areas.
3. Technical Providers: Local companies offering digital agriculture solutions can offer new services based on the tools developed and validated in the demonstrator.

3.3.8.9 User Needs and Expectations

Farmers need systems to protect them from extreme weather events, mainly the increased frequency and severity of drought predicted for this region. This will considerably affect their farms' production, requiring adaptations for which advisory services and new information provided by sensors and satellites is demanded.

The cooperative's technical staff will provide the advisory services needed, based on new information about grassland productivity at the field scale.

3.3.8.10 . Evaluation Objectives

The objective of the evaluation at this stage is twofold. First, we aim to validate the product further at the farm scale by utilizing data from several farms provided by the cooperative. Second, we intend to share the results of these analyses with the cooperative staff and a small group of farmers selected by the cooperative. This collaboration will help us design the main features of the future service, with a primary focus on its usefulness and usability.

3.3.8.11 Evaluation Approach

Evaluation approach integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders (see Annex 3). Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions.

The first demonstration event was held on February 13, 2025, at the cooperative's facilities. It was attended by cooperative technical staff and researchers from the University of Córdoba. During this event, IFAPA presented the tool that is currently being developed to provide information on grassland productivity, showcasing several examples of results obtained from specific farms. This allowed participants to provide feedback on the product's utility, preferred spatial scale, usefulness, and suggestions for improving future services.

A second demonstration event is scheduled for March 10 at the same location and will involve the owners of the analyzed farms. Organized by the cooperative, this event will feature the initial results obtained from their farms, enabling further evaluation.

Additional demonstration events will be organized during the second iteration in collaboration with the cooperatives, aiming to include a broader group of cooperative members interested in participating in this evaluation phase.

3.3.8.12 Key Performance Indicators (KPIs)

The demonstrator developments contribute to the following KPIs:

- KPI.O1: Implementation of sensor and sampling innovations.
- KPI.O4: Adoption and demonstration of data sharing best practices
- KPI.O7: Development of improved or new data products
- KPI.O8: Utilization of improved data products by RILs to optimize services to farmers
-
- KPI.I1: Number of newly developed Smart Farming solutions
- KPI.I2: Number of regions where these solutions were tested.
- KPI.I3: Number of engaged potential users for all Smart Farming-related data products.
- KPI.I4: Number of agri-environmental soil and crop parameters covered.
- KPI.I5: Number of regions where these solutions were tested.
- KPI.I6: Number of engaged potential users for each soil and crop-related data product.
- KPI.I7: Number of project agriculture data products that are of interest for the “Agriculture of Data” partnership.
- KPI.I8: Number of developed services and data that are of interest to the R&I mission on soil health.
- KPI.I16: Number of engaged users.
- KPI.I17: Number of co-design workshops.

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Number of Young People Engaged in Learning About Modern Agricultural Technologies or Participating in Specialized Training Programs

A favorable effect is expected, with a projected increase of 15-30 young farmers trained per year through 1-2 specialized courses. Currently, training programs do not incorporate modern technologies

such as sensors and remote sensing for grassland management. Integrating these advancements into future courses can enhance agricultural knowledge, encourage young people to become farmers, and contribute to rural economic growth by creating sustainable employment opportunities.

KPI 2: Number of Participants in Project Workshops and Demonstrations. A favorable effect is estimated, with increase to at least 20 participants per event. Workshops and demonstrations can expand awareness and adoption of innovative agricultural tools, helping farmers, cooperative staff, policy makers, and researchers enhance productivity and efficiency in the sector. Participation can be measured through attendance records and questionnaire responses, supporting engagement and knowledge transfer.

KPI 3: Number of Stakeholders Reached/Informed with Newly Developed Products and Services. A favorable effect is expected, with a projected outreach of 30 stakeholders. The initiative can provide essential information and tools related to agricultural sustainability and drought resilience. By informing farmers about growth and climate-related solutions, this KPI can support better decision-making and adaptation strategies in grassland management, strengthening long-term agricultural sustainability.

KPI 4: Number of Scientific and Methodological Publications in Relation to Grassland Productivity A favorable effect is expected, with a projected increase of three scientific publications. These publications can contribute to knowledge transfer, improve awareness of digital technologies in agricultural risk management, and support policy makers and public authorities in making informed decisions. By integrating research into practice, the initiative can advance scientific understanding and application in grassland productivity.

KPI 5: % Increase in Datasets Available to Support Scientific Research and Technology Development The effect is currently uncertain, with an expected percentage increase in datasets depending on implementation. The creation of new datasets can support further scientific research and technological advancements, benefiting researchers and developers. The extent of impact can depend on the availability and accessibility of data for future studies and applications in precision agriculture.

The **solutions and methodologies** developed are expected to support **Smart Farming & Agri-Environmental Monitoring** by strengthening food system resilience and promoting sustainable farming (**EU Green Deal Goals a & c**). Engaging young farmers in modern technologies can enhance **climate-smart agriculture** and **environmental monitoring**, reinforcing **CAP policies** for sustainable farming. While the impact depends on implementation, these efforts could contribute to the **economic and environmental performance of the agricultural sector**.

3.3.8.13 Foreseen Risks

- Accurate information about current stocking rates and the physiological state of the animals is needed to assist in validating the product. Several assumptions and bibliographic information are being used to complement the analysis.
- The years of high spatial resolution data (Sentinel-2) available are too reduced to account for extreme climate events. However, despite this limited number, the last two growing seasons represented opposed extreme conditions, providing a reasonable estimation of extreme values. Comparing with a more extended series of data at a lower spatial resolution can be used to evaluate the impact of this risk.

- The cooperative decide that it will not prioritize this tool in its app programming schedule in the future. Up to now, they have shown great interest in this development, and we will continue to count on their collaboration to improve the service.

3.3.8.14 Feedback from participants

The following feedback was collected from the stakeholders during the first Demonstration event. The initial results obtained from several farms provide a clear picture of the potential of the proposed tool. This analysis, based on data from the last few years (2021-2024) seems accurate enough. The cooperative's technical staff's experience supported some decisions about the livestock needs and energy the grassland provides, which are required to validate the grassland productivity product at the farm scale.

High spatial resolution data for each field is crucial for enhancing grassland management on the farm. This level of detail allows farmers to identify significant phenological differences between fields. Farmers prefer high spatial resolution data over lower resolution products, even if the latter offers a greater number of years of data, as this could enhance the representation of extreme values. Experienced older farmers generally possess a better understanding of grassland productivity than younger farmers, making them an essential target user group for this product. Several factors, such as the available workforce on the farm, will influence farm management independently of its productivity.

Privacy issues must be addressed during the implementation of the service to ensure that only owners can access information at a high spatial resolution, while only general information is made publicly available.

3.3.8.15 Future Developments Planned Improvements for 2nd Iteration

In the second iteration, we will continue to collaborate on the tool's design by involving more farmers to further evaluate the proposal. The cooperative's newsletter will share these updates and encourage new users to participate.

3.3.8.16 Scalability and Replication

Once the demonstrator is implemented, it can be scaled up with minimal effort, as long as the ecosystem and climate characteristics are similar. This would encompass comparable oak savanna areas in the Mediterranean region, which includes approximately 3 million hectares in Spain and Portugal alone.

3.3.8.17 Supporting Materials - Images/Diagrams



Figure 21: Distribution of farms selected for a first assessment of grassland productivity under extreme climate conditions and testing of the proposed tool

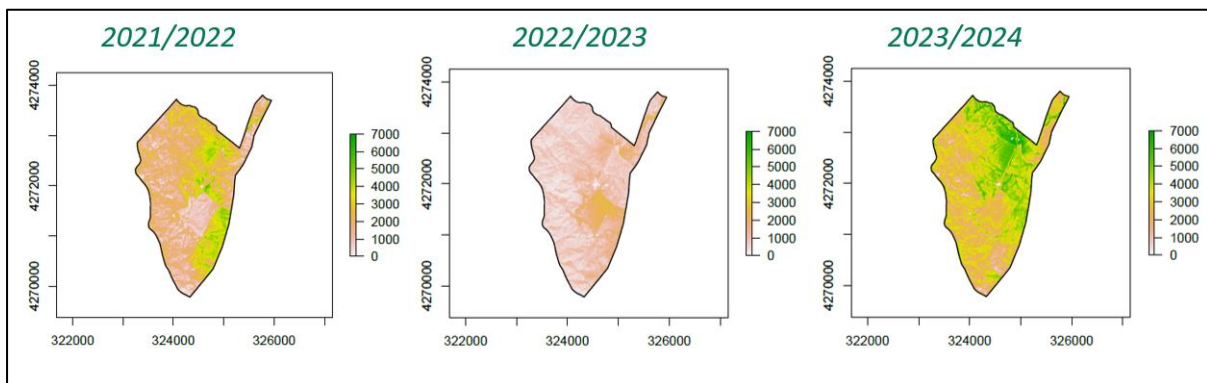


Figure 22: Example of a farm's accumulated grassland net primary production in kg/ha over the last three years, including a regular growing season (2021-2022) and two years of climate extremes (2022-2023 and 2023-2024).

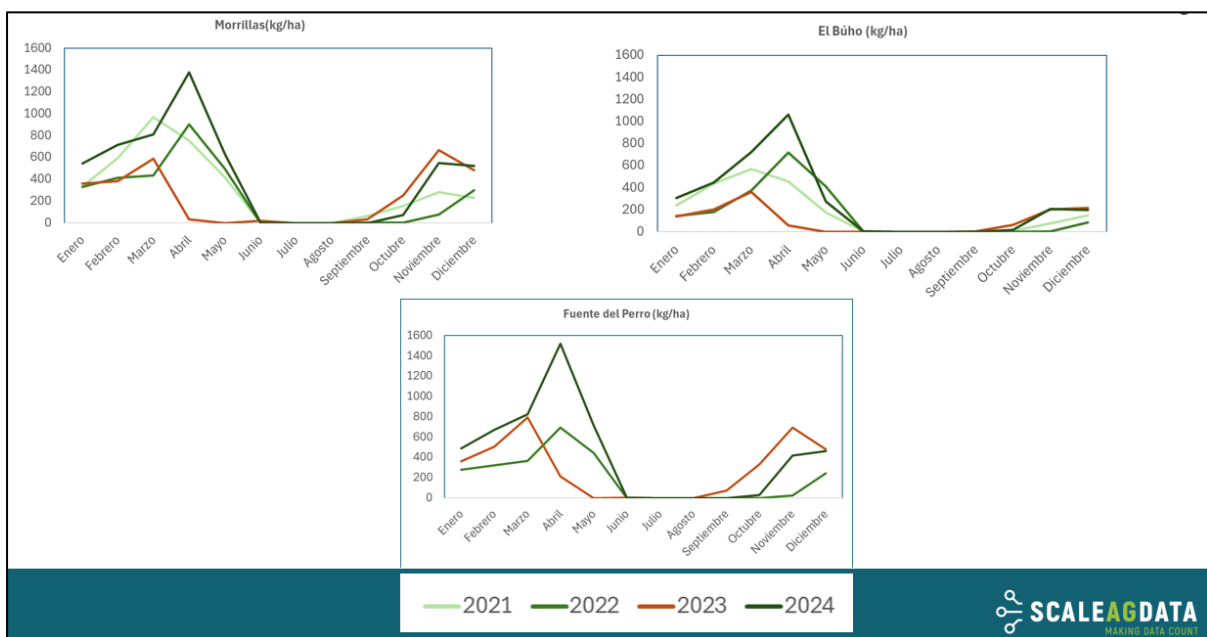


Figure 23: Monthly evolution of grassland productivity in three farms during the last four years.

3.3.8.18 Relevant Documentation

There are no further relevant documents.

3.3.9 RIL5.2 – Monitoring the productivity of mountain grasslands

3.3.9.1 Demonstrator Overview

Thematic focus: Grassland monitoring in the European Alps by remote sensing and in situ data.

Main Objectives:

- Fuse optical and radar data by machine learning models to improve the temporal resolution of grassland biophysical parameters (LAI) derived from Sentinel-2 and monitor grassland conditions all over the growing season.
- Collect a robust dataset of in situ measurements to validate the ML data fusion models.
- Enhance the methodology that informs an index-based insurance to protect mountain grassland against yield losses due to drought events

3.3.9.2 General Description

Regular monitoring of grasslands productivity is important for a sustainable use of their resources and understanding how ongoing and predicted extreme events impact their productivity and the adaptations needed in their management. The overall objective of this demonstrator is to develop a system to estimate the yield of mountain grassland ecosystems, using ground sensors and state-of-the-art data fusion technologies to make the most out of optical and radar satellite data for the derivation of grassland biophysical parameters. Spatially distributed in situ measurements of grassland quantitative traits are collected, for the validation and/or calibration of yield and biophysical parameters. If satisfactory in terms of accuracy, the output will inform index-based drought insurance, letting farmers protect their income from yield losses, avoiding land abandonment and the related consequences on landscape conservation, soil quality, and biodiversity.

3.3.9.3 Technologies Used

The following technologies were used within the demonstrator:

Earth Observation (EO) Data: Satellite-based EO data, multispectral and SAR data, are utilized for regional scale grassland monitoring.

In situ data: In situ measurements of soil moisture, grassland leaf area index, fAPAR, height, and weight are performed following a specific protocol that is suitable for the validation of satellite-based products. This data is also useful for understanding the specific conditions in the fields and their effect on the signals observed by satellite sensors.

Data Fusion: Advanced techniques for data fusion are applied to combine multi-sensor EO data (Sentinel-2 MSI, Sentinel-1 SAR).

Collaborations: Key technical providers within ScaleAgData include DEIMOS offering methodological support relative to the development of machine learning models. In the framework of a research stay at EURAC, a researcher from IFAPA will test the applicability of the demonstrator also in the RIL5 study area in Spain.

3.3.9.4 Deployment Information - Timeline

The demonstrator is currently under development, with a phased deployment plan:

First Iteration (Early 2025): The initial version of the demonstrator is expected to be ready in the first months of 2025. This phase will focus on the finalization and validation of the machine learning model to fill the gaps in Sentinel-2 LAI using SAR data from Sentinel-1.

Second Iteration (End-2025): In the second iteration, the demonstrator will expand its capabilities to estimate grassland yield by calibrating a model to derive yield from LAI based on in situ data, and upscaling it to satellite-based LAI maps to estimate spatially distributed grassland yield.

These iterations will provide a progressive enhancement and upscaling of the demonstrator's functionalities. The final deployment is expected to incorporate feedback from the first iteration and focus on further refining the tool.

3.3.9.5 Integration with Existing Systems

The demonstrator will be integrated into the end-user applications developed by EURAC as part of projects funded by local authorities (Department of Agriculture of the Province of Bolzano). It will function as an upgraded version, building on previous developments with enhanced capabilities and features. Key improvements can include, based on evaluation results:

1. Use of SAR data to fill the gaps in the LAI timeseries estimated from Sentinel-2
2. Use of all the in situ data collected during the project to validate the LAI estimates and derive a relationship between LAI and yield.

3.3.9.6 Deployment Locations

The demonstrator will be deployed across eight parcels belonging to three grassland farms in the province of Bolzano, Italy. These farms were selected based on the availability of the farmers to have researchers on their fields to perform in situ measurements. Spatially distributed data will be derived also for several other farms distributed all over the region, where no validation data is available.

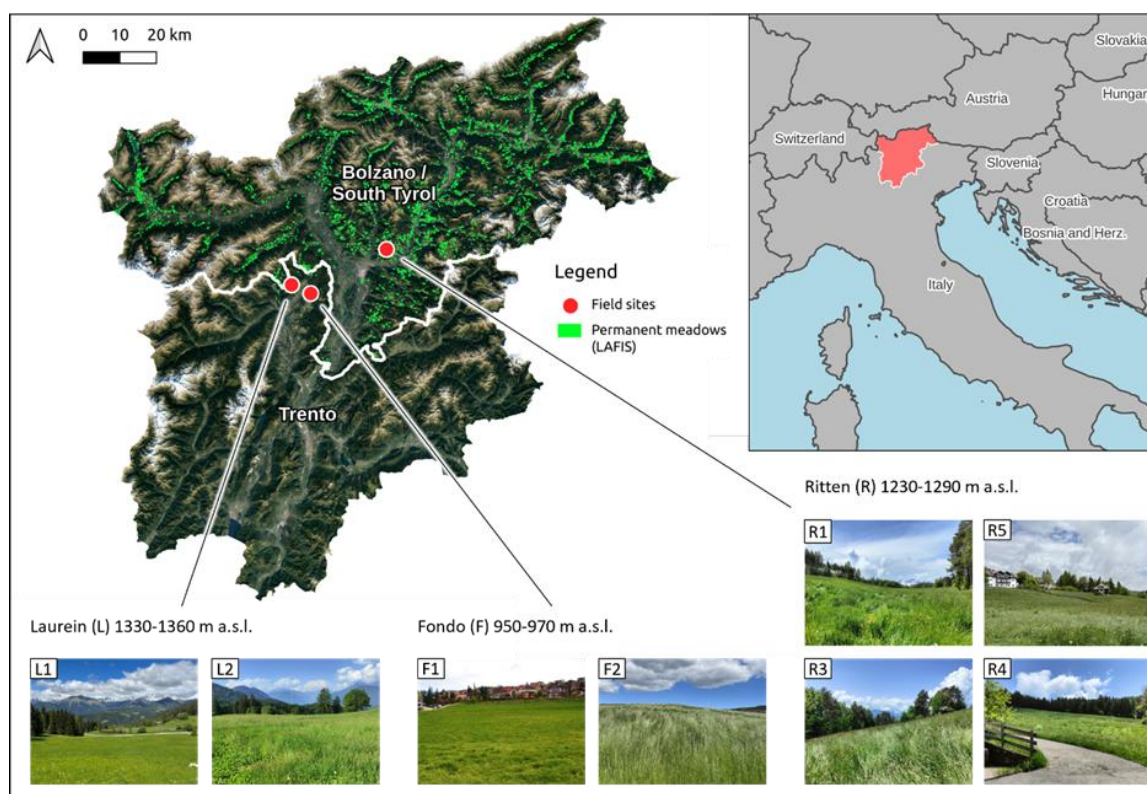


Figure 24: Location and pictures of the pilot parcels. Imagery: Google, © TerraMetrics.

3.3.9.7 Primary End-users

1. Farmers and Agricultural Co-operatives: Small and medium-scale farmers, as well as agricultural cooperatives in the Province of Bolzano, Italy, are key end-users. The demonstrator provides insights into the impact of drought events on the yield of their fields
2. Insurance companies: Insurance companies can set insurance policies with the farmers' associations based on methods developed by the demonstrator.

3.3.9.8 Target Groups

1. Local authorities: the department of Agriculture of Bolzano benefits from the introduction of innovative digital technologies in agricultural risk management.
2. Research Institutions: Agricultural researchers and institutions will be able to use the in-situ data that the demonstrator collects for the validation of satellite products over mountainous terrain and the methods that the demonstrator proposes for applications in similar areas.
3. Technical Providers: Local companies offering digital agriculture solutions can offer new services based on the tools developed and validated in the demonstrator.

3.3.9.9 User Needs and Expectations

- **Farmers associations** act as mediators between farmers and insurance companies. They prepare the insurance contracts and need to receive an estimate of the yearly yield fluctuations

- to inform a parametric insurance system against drought events.
- **Farmers** need systems to protect them from extreme weather events.
 - **Insurance companies** need validated methodologies to estimate yield losses and inform an insurance policy.

3.3.9.10 . Evaluation Objectives

The aim of this evaluation is to gather information and address challenges related to the implementation and effectiveness of a parametric insurance policy for alpine meadows against yield losses due to drought events. The questions are directed at the main stakeholder, the Hagelschutzkonsortium - Confindesa of Bolzano.

The main aspects covered by the questions include:

- General Questions: Expectations and benefits of using satellite data for meadow insurance.
- Potential Challenges: Issues foreseen in adopting this technology.
- Technical Aspects: Accuracy and importance of satellite data.
- Implementation and Use: Steps for integrating satellite data into existing insurance models and ensuring data transparency.
- Economic Considerations: Cost-effectiveness and pricing models for insurance premiums.
- Stakeholder Involvement: Key stakeholders and methods to engage local communities and farmers.
- Future Perspectives: Expected advancements in satellite technology and its role in agricultural insurance.
- Evaluation of Data: Quality and improvements of the satellite data provided so far

3.3.9.11 Evaluation Approach

Evaluation approach integrates quantitative and qualitative methods to assess impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For added value assessment, structured questions were developed to gather feedback from external stakeholders (see Annex3). Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation and continuous improvement of the solutions.

To evaluate the demonstrator, EURAC organizes a two-hours workshop in person with the stakeholders. During the workshop, EURAC will present the activities performed in ScaleAgData, including the validation, limitations, and issues encountered in the development phase. EURAC proposes to the stakeholders a questionnaire to cover all the aspects listed above, in the section “Evaluation Objectives”.

3.3.9.12 Key Performance Indicators (KPIs)

The demonstrator developments contribute to the following KPIs:

- KPI.O1: Implementation of sensor and sampling innovations.
- KPI.O4: Adoption and demonstration of data sharing best practices

- KPI.O7: Development of improved or new data products
- KPI.O8: Utilization of improved data products by RILs to optimize services to farmers
-
- KPI.I1: Number of newly developed Smart Farming solutions
- KPI.I2: Number of regions where these solutions were tested.
- KPI.I3: Number of engaged potential users for all Smart Farming-related data products.
- KPI.I4: Number of agri-environmental soil and crop parameters covered.
- KPI.I5: Number of regions where these solutions were tested.
- KPI.I6: Number of engaged potential users for each soil and crop-related data product.
- KPI.I7: Number of project agriculture data products that are of interest for the “Agriculture of Data” partnership.
- KPI.I8: Number of developed services and data that are of interest to the R&I mission on soil health.
- KPI.I16: Number of engaged users.
- KPI.I17: Number of co-design workshops.

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: Transparency in Indemnity Calculation

A moderate impact has been reached, with indemnities now based on drought indices correlated with yield losses using in situ measurements. Previously, calculations relied on sparse meteorological stations, which had little correspondence with actual losses. A high positive impact is expected as further improvements are made, including additional seminars to refine calculation methods and improve farmer understanding and trust in the process.

KPI 2: Stakeholder Engagement

A high level of engagement has been reached, with one consortium and one local authority actively participating and showing strong interest in improving the technology. Previously, participation was low, with only preliminary discussions and tests. A moderate increase in trust is expected as efforts continue to maintain stakeholder involvement, ensuring their confidence in the proposed methodologies while keeping the scope focused on research.

KPI 3: Community and Farmer Engagement

More than 100 farms are now insured through a co-developed parametric scheme, and two seminars have been conducted with local farmer consortia. This marks a significant improvement from the initial stage, where only four farmers participated in preliminary tests. A further positive impact is expected by increasing farmer awareness of satellite data benefits, with a planned seminar directly addressing their concerns and improving understanding.

KPI 4: Cost Reduction

A moderate reduction in costs has been reached, as parametric insurance has proven to be significantly cheaper than traditional physical assessments. However, data processing still requires a substantial amount of manual work, keeping expenses relatively high. An additional cost reduction is expected as automation processes are implemented to streamline data generation and improve efficiency.

KPI 5: Accuracy of Damage Assessment

The accuracy of satellite-based assessments has improved, with validation results from 2023 showing an r^2 of 0.62 and an RMSE of 1.82, which increased to an r^2 of 0.78 and an RMSE of 1.5 in 2024. While these results represent substantial progress, further refinement is expected through expanded validation studies. The goal is to maintain or enhance accuracy while integrating ScaleAgData’s gap-filling methods.

KPI 6: Availability of In Situ Data for Validation

Eight fields were monitored biweekly from April to October 2023 and 2024, covering the full growing season and collecting key biophysical parameters (LAI, fAPAR, yield) along with additional ancillary data. Currently, accessibility is restricted within the lab. A significant improvement in data availability is expected as efforts are made to ensure open access upon publication.

KPI 7: Capacity Building for Agricultural Monitoring

Initial steps have been taken, with plans in place for co-organizing learning sessions at scientific conferences (ESA Living Planet Symposium, IGARSS 2025). The expected outcome is an increase in researcher participation in training sessions, strengthening expertise in using big data for agricultural monitoring. Future reporting will track the number of attendees and engagement levels.

The **solutions and methodologies for parametric insurance and agricultural monitoring** are expected to support **Farm to Fork Strategy** and **EU Green Deal goals** by improving risk management, efficiency, and data accuracy. **Enhanced indemnity calculation (KPI 1)** and **damage assessment (KPI 5)** strengthen the **resilience of the EU food system**, while **stakeholder engagement (KPIs 2 & 3)** fosters trust in sustainable farming technologies. **Improved in situ data (KPI 6)** and **capacity building (KPI 7)** contribute to **environmental monitoring** and **CAP policies** supporting sustainable agriculture. **Cost reductions (KPI 4)** align with **SDG 12 (Responsible Consumption & Production)** by making agricultural monitoring more efficient. While the full impact is uncertain, these efforts aim to enhance sustainability and competitiveness in digital farming.

3.3.9.13 Feedback from participants

- **High implementation cost:** Adopting new technologies can involve significant costs.
- **Reliability and accuracy of measurements:** There are concerns about the accuracy of satellite data, in particular about the integration of SAR data which has not shown advantages so far.
- **Complexity in integrating with existing insurance systems:** Integrating new data with current systems can be complex.
- **Privacy and data management concerns:** Managing personal data and privacy are critical aspects.
- **Lack of familiarity with the use of satellite data in the agricultural sector:** Users may not be accustomed to using satellite data.

3.3.9.14 Future Developments Planned Improvements for 2nd Iteration

- Explore partnerships with local technology providers for cost-sharing opportunities.
- Invest in advanced satellite technologies and algorithms to enhance data accuracy. Regularly validate satellite data with ground-truth measurements.
- Develop standardized protocols for seamless integration. Provide training and support to farmers associations for smooth adoption.

- Implement robust data encryption and anonymization techniques. Ensure compliance with data protection regulations and maintain transparency with users about data usage.
- Conduct workshops and training sessions for farmers and their consortia. Provide user-friendly tools and interfaces to simplify data interpretation

3.3.9.15 Scalability and Replication

Regional scale: The demonstrator was implemented and validated over eight alpine meadows in the province of Bolzano, Italy. The main input data was processed to cover the entire province. After further developments and validation, if the developed gap-filling and data fusion methodologies are satisfactory in terms of accuracy, the demonstrator can be integrated in the insurance system that is under development and applied to the regional scale.

Different climatic regions: The methodologies developed for alpine meadows will be replicated in Mediterranean oak savanna grasslands, an ecosystem crucial for rural development but highly sensitive to water availability and climatic variability. With the support of a PhD student from IFAPA, who is conducting a visiting period in Eurac, optical and radar data will be fused using machine learning models to enhance the temporal resolution of biophysical parameters like LAI from Sentinel-2. A robust dataset of in situ measurements will be used to validate the data fusion approach and assess its adaptability to different climatic and management conditions.

3.3.9.16 Supporting Materials - Images/Diagrams

There are no further supporting materials.

3.3.9.17 Relevant Documentation

There are no further relevant documents.

3.3.10 RIL6.1 – Milk quality forecasting

3.3.10.1 Demonstrator Overview

Thematic focus: Planning processes of dairy cooperative

Main Objective:

Data sets at hand are correlated with indicators relevant for performance of dairy farms in a specific and homogeneous area. The demonstrator is using meteorological data and in-situ data.

Milk quality forecasting can be effectively achieved by utilizing parameters that exhibit high correlation coefficients based on the conducted correlation analysis. The demonstrator builds upon predictive models to enable milk quality forecasting.

3.3.10.2 General Description

The dairy cooperative is planning the production program and controls all related processes from milk transport up to production planning and control in the related factories that represent the domain of process industry.

The demonstrator aims at providing milk quality predictions for the forecast horizon of ECMWF weather forecasts to support and investigate possible application within the above-mentioned duties of the dairy cooperative. The demonstrator's validation is the prerequisite to enable the scaling towards extended usage of EOD in other regions, even possibly reducing the required usage of historic in-situ data. Furthermore, the demonstrator aims at combining data from dairy farmers, and milk laboratories.

The demonstrator presents initial projections of the quality of the processed milk. The demonstrator provides an analysis and visualisations of the milk production over different years and in typical periods of time. Therefore, it enables the discussion of forecasting results over different regions and type/size of dairy farms.

3.3.10.3 Technologies Used

The demonstrator is based on historical in-situ data, provided by dairy farms, milk laboratories and the dairy cooperative. This data was gathered making use of the milk collection transports. For real-time forecasting within RIL 6, latest dairy data will be made accessible via an SFTP-server. Moreover, meteorological data was gathered and merged from related EOD-based sources such as Copernicus ERA5 and ECMWF forecasts to provide seamless time series used as covariates within the prediction models. Initially, also aggregated data from farm equipment telemetry was used to generate input data.

The gathered data was analysed, using different time series forecasting models. The demonstrator is running on a virtual machine, accessible with standard web browsers, enabling developers to define parameters of forecasts and the related time horizons as well as enabling end-users to visualize milk quality forecasts.

3.3.10.4 Deployment Information - Timeline

The current version of the demonstrator has a TRL of 5. The initial deployment and demonstration is based on historical data. The demonstrator will be extended with the daily import of operational data in spring 2025.

3.3.10.5 Integration with Existing Systems

The demonstrator served for the validation of the current operational processes that are generally supported by the existing legacy systems. The latest demonstrator version made use of individual and manually initiated data exports from the running ERP system. The team already agreed on an interface specification to feed the demonstrator with daily data exports about milk production.

3.3.10.6 Deployment Locations

The demonstrator is addressing regions in Northern Germany between the rivers Weser and Elbe, specifically between the cities of Bremen and Stade. This region incorporates hundreds of farms of different size, while the geographical and meteorological characteristics are rather homogeneous. The first dairy lab demonstrator is realised in Northern Germany, between Bremen, Hamburg and Stade, located in the Atlantic biogeographic region. Every dot on the map below represents a dairy farm that is delivering their milk to the dairy cooperative.

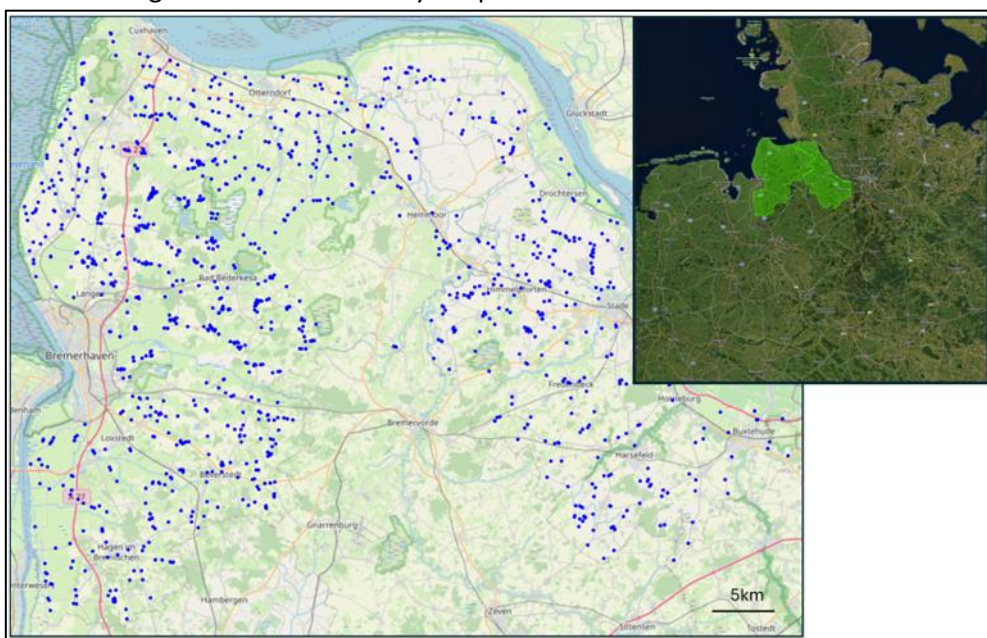


Figure 25: Map of deployment locations.

3.3.10.7 Primary End-users

In general, the dairy cooperative is the primary end-user of the demonstrator. Different departments/organisational units are envisaged to benefit from the solution. In a first step, specifically the departments responsible for the collection of milk up to the subsequent milk processing in factories at several locations are expected to benefit in the scope of transport planning and optimisation in relation to the production programme. Moreover, the cooperative's sales planning can benefit from an improved forecasting, enabling to minimise waste and optimise sales towards the retailers.

3.3.10.8 Target Groups

The milk processing facilities themselves are also considered as an additional target group, to make use of a better milk quality forecasting system in the scope of the detailed planning of the production

schedule. It is expected that this will reduce setup costs, waste of input produce and facilitate an optimisation of the product mix, taking into account the machine occupancy planning and the related contribution margin of the individual products.

3.3.10.9 User Needs and Expectations

Currently available forecasting figures are based on average milk quantities rather than on detailed prediction of potential milk quality. This is not necessarily matching the required detail that could enable the described benefits, and this manually driven process cannot react in a timely manner to short-term deviations or even realise daily calculation of forecasting figures based on the real-time availability of laboratory results.

3.3.10.10. Evaluation Objectives

The evaluation aims at validating the usefulness of the forecasting data for the different target audiences. This includes the validation of the representation of data for daily use, the detail of data that could be made available as well as discussing the requirements with respect to the required accuracy of forecasting data. At the same time, the aim is to evaluate if there are specific parameters that have known correlations with milk quality data or could have potential to cause/explain unexpected deviations, hence having an impact on the accuracy of the milk quality data forecasting. On top of that, the evaluation aimed at a comparison of the current forecasting procedure with a potential new approach, including the required effort and time to prepare related overviews, as well as evaluating the possibilities to integrate a new solution into the current infrastructure and procedures.

3.3.10.11 Evaluation Approach

The evaluation approach integrates quantitative and qualitative methods to assess the impact and added value. The impact assessment is based on initial KPIs from the grant agreement, complemented by lab-specific KPIs, with both quantitative and qualitative data collected from RIL partners to evaluate societal, economic, technological, and environmental contributions.

For an added value assessment, structured questions were developed to gather feedback from external stakeholders. Data was collected through surveys, interactive methods like Mentimeter, and interviews, ensuring a comprehensive evaluation.

The demonstrator event was a kick-off to inform the related target groups about the latest developments, achievements and next steps towards a more thorough evaluation in the daily business, based on the continuous import of operational real-time data as well as related weather forecast data. The milk quality forecast data will be compared with the usual procedures in place. The evaluation will also address the level of detail, the possible frequency to prepare forecasts as well as the granularity of the forecasts, taking into account the smallest resolution to be taken into account for the forecasting.

The evaluation will include an analytical part of comparing different forecasting models as well as comparing the forecasting data with the measured data as soon as the real-world data is available. The usage of the demonstrator will be further evaluated by the related target groups to collect further feedback information.

3.3.10.12 Key Performance Indicators (KPIs)

The following KPIs were taken into consideration for the demonstrator:

- RILs adopt and demonstrate data sharing best practices. The sensor data is readily available according to the metadata and governance models. The focus is on meteorological data that can be integrated into the forecasting.
- Development of new data products which are available to the different stakeholders, both within the RI labs and to other stakeholders and cover the different environmental axes (water, air, soil and living organisms). The focus is on milk quality data forecasting as data product.
- The improved data products are evaluated by different users (both from within as outside the consortium) on their relevance and useability
- Number of regions where these solutions will be tested. Considering “region” as homogeneous area with respect to the weather conditions and type of farms. Additional regional aspects are related to the production facilities and the distribution/sales to retailers.

Contributions to Wider Impacts

Below, additional KPIs have been developed to facilitate a more robust assessment of impacts related to the Green Deal, SDGs, and broader sustainability objectives (see Annex 2).

KPI 1: % Improved Forecast Availability of Milk Quality Data – Very favorable effect is estimated with a target of 100% improvement in milk quality forecasting, enabling daily predictions. Currently, only milk quantity is forecasted, while fat and protein levels are not considered. Integrating milk quality data into forecasting systems will enhance production planning and reduce uncertainties. This will **improve supply chain efficiency, reduce financial risks, and enhance market competitiveness while also advancing scientific research in precision farming and AI-driven dairy analytics.**

KPI 2: % Reduction in Security Margin for Sales Planning – Uncertain effect with an estimated target of 5% decrease in security margin for balancing milk input and output. The current high security margins exist due to unreliable forecasts, and while better forecasting could reduce them, it may not eliminate the need for excess stock. Additionally, unused milk still needs to be processed into milk powder, requiring more energy and offering lower profitability. If successful, this could **lower costs, reduce waste, and improve efficiency**, but the extent of these benefits remains uncertain.

KPI 3: % Reduction in Additional Milk Transport Between Facilities – Favorable effect is estimated with a target of 50% decrease in unnecessary milk transport between facilities. Currently, due to inaccurate fat and protein forecasts, milk is frequently transported between production sites to meet requirements. Improved forecasting will enable more efficient milk allocation, reducing transport needs. This will lower transportation costs, **increase profitability, and significantly reduce CO₂ emissions, contributing to more sustainable dairy production.**

KPI 4: % Reduction in Costs Associated with Batch Changes in Production Facilities – Uncertain effect with an estimated target of 5% decrease in cleaning and downtime costs due to optimized planning. Reducing batch changes could lower costs, but the current production system prioritizes flexibility with higher security margins, which might limit the potential impact of optimization. While **efficiency**

improvements and cost reductions are expected, the real impact will depend on whether production planning can be adjusted without compromising operational flexibility.

The solutions and methodologies developed by the Dairy Lab can contribute to sustainability and efficiency in milk production by improving forecasting, optimizing resource use, and reducing waste. This aligns with the **Farm to Fork Strategy, the European Green Deal, and SDG goals** like responsible consumption (**SDG 12**), clean water (**SDG 6**), and food security (**SDG 2**). Reduced transport emissions might also have an indirect impact on climate action (**SDG 13**). While the actual impact remains uncertain, these advancements have the potential to support smarter farming and a more sustainable dairy sector.

3.3.10.13 Foreseen Risks

General IT security restrictions could hamper the export of internally available data to an external system on a larger scale. However, the close involvement of the innovation and IT department enables an early validation of the architecture of the envisaged demonstrator and future solutions.

3.3.10.14 Feedback from Participants

The demonstrator was presented and discussed with the target audience. The following feedback was collected accordingly:

- The comprehensive visualisation of the underlying approach to calculate a forecasting of the milk data helped the target audience to understand which data and parameters are representing the baseline for realising the demonstrator. This enabled us to understand the evolution from current practices towards a new approach.
- The current forecasting is focussing on milk quantity rather than milk quality, since this is not possible to forecast based on the current approach. However, since the data used in the demonstrator was representing a rather homogeneous agricultural region, the feedback was received to further analyse differences of small and large dairy farms, since past experience shows that the milk quality parameters differ, due to different approaches and timing for milking the cows.
- The presented accuracy of the initial forecasting based on historical data seems to be accurate enough. However, it was agreed to further validate the forecasting based on operational data and latest weather forecasting data, instead of using just historical data sources.
- The envisaged usage of operational data delivered by the milk laboratories might not be realised daily, as data of latest milk production becomes available with delays of 1-3 days, taking into account the organisation of work at the farms, transport and laboratories. The data transfer schedule is also deviating with respect to different IT systems, taking into account their purpose and end-users.
- The usage of historical data that is representing exceptional seasons and/or parameters (e.g. due to a drought or specific political decisions) might be neglected, since it could influence the model training with a bias that is not relevant in usual years.
- Current forecasting of milk quantities is done on a monthly basis. Milk quality is only considered based on average values. There are no daily refinements of the projections. Therefore, an operational usage of the demonstrator at a later point in time and beyond the project scope should also discuss the operational concept from an organisational as well as technical perspective.

- The availability of milk quality was considered very useful also for the milk transportation to the different factories, since the transport planning could be enhanced by balancing available fat quantities with the fat quantities required for realising the production programme. This could avoid waste or the realisation of sub-optimal production plans.

Another interaction with external stakeholders took place during the interactive session held as part of the organized demonstration on February 10. Feedback was collected from external stakeholders representing various target groups (see Annex 3). A total of 27 external stakeholders were reached, with varying levels of participation across different questions, ranging from 13 responses to as few as 4. Open-ended questions generally received fewer responses, suggesting that structured questions were more engaging for participants. The corresponding responses gathered from the targeted questions are as follows:

- The majority of participants (52%) come from the scientific community and academia, while 33% represent SMEs, agribusiness, and agritech companies. Farmers, advisors, and their associations account for 15%, whereas policymakers and public authorities make up only 4%. Other technology providers represent 11%, but the insurance sector, European institutions, and general public consumers are entirely absent.
- Forecasting specific parameters is already in use by 38% of participants, while an equal percentage do not currently employ forecasting methods. Additionally, 23% are planning to implement it in the future. This indicates that while many organizations already rely on forecasting, there is still room for wider adoption. Among those using forecasts, key parameters include weather-related data such as temperature and rainfall, as well as soil conditions, milk composition (e.g., alpha casein percentage), and market factors like commodity prices. The range of monitored variables highlights the diverse applications of forecasting, from environmental monitoring to agricultural production and economic trends.
- Weather forecasting data is widely used, with 64% already incorporating it into their work, while 18% do not use it, and another 18% plan to start using it. The sources of this data vary, with commercial providers being the most common, alongside ECMWF, ERA-5, e-DWIN, and various websites. The reliance on multiple sources highlights the need for diverse and reliable weather information to support agricultural and business decision-making.
- The forecasting horizon varies among participants, with some relying on short-term predictions of 1–10 days, while others extend their forecasting range to 1–45 days or even attempt seasonal forecasting. This reflects different needs and strategies in how forecasting is applied across different projects and organizations.
- The developments presented were met with strong interest, as 67% of participants found them very interesting, while the remaining 33% considered them somewhat interesting. No one expressed neutrality or disinterest, indicating a generally positive reception. Participants highlighted several reasons for their interest, including the potential for advancing agriculture and animal welfare, improving collaboration between industry stakeholders, policymakers, and researchers, and enhancing data aggregation along agricultural production chains. Some also recognized specific benefits for dairy production management. These insights demonstrate the perceived value of the developments across various agricultural and research sectors.

3.3.10.15 Future Developments and Planned Improvements for 2nd Iteration

The initial demonstrator shall use operational data in its next iteration. This will be accomplished by integrating with an existing system that is gathering and distributing milk data from farms and laboratories. At the same time, a reusable service will be integrated to receive meteorological weather forecast data. The related end-user interface will be updated, to facilitate the request of related forecasts.

The main improvement will be the definition, usage and analysis of different forecasting models with respect to their accuracy. Since this is a rather abstract work, there will be elements for an automatic selection of models to be used, as well as gathering the related data for subsequent analysis cycles. The architecture of the overall system will be further validated and adjusted, taking into account the current systems in the cooperative.

Elements for the secure use & distribution of data and enabling access will be further refined, to enable the support of later operational use in such a large cooperative.

3.3.10.16 Scalability and Replication

The first demonstrator is focusing on a specific homogeneous region. Further regions shall be identified by related experts in the cooperative. It was already agreed that it does not make sense to focus on individual farms, but on regions that are homogeneous in terms of weather, farm sizes and other parameters still to be defined. From a technical/theoretical perspective, it is limited to the minimum size for the area of available weather forecast data. From a cooperative perspective it might also relate to certain organisational regions. However, this will be further analysed and requires the configurability for different regions that shall be defined by related polygons.

Since the historical milk data is a basic element to train the forecasting models, any replication would require a kind of similar setting with regard to number of farms and availability of data.

The general scalability seems to be technically rather manageable, due to the possibility to separate the forecasting for specific regions and enable distributed computing in a data centre. At the same time, also user management seems not to disturb the extended use of the demonstrator or later commercial versions of the system.

3.3.10.17 Supporting Materials

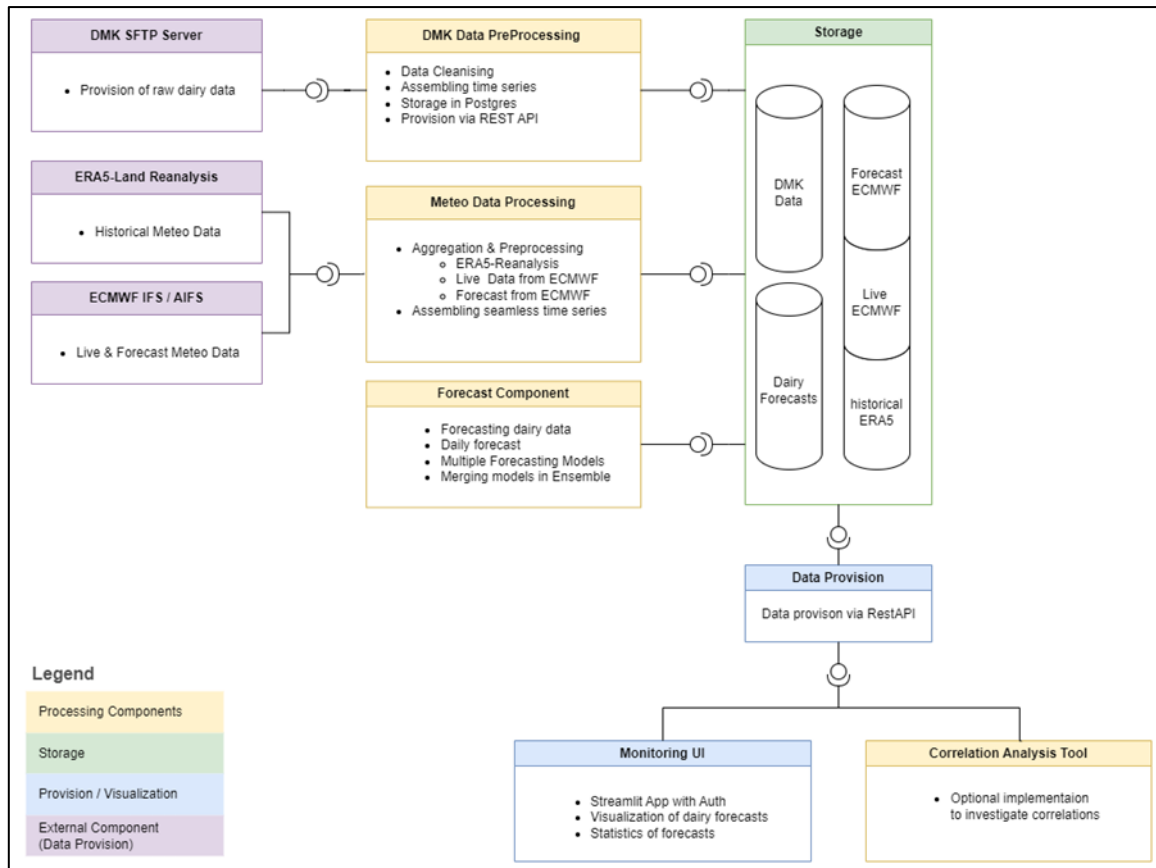


Figure 26: Architecture draft for the implementation of the RIL6 demonstrator. All components run as docker containers on a virtual machine.



Figure 27: Dashboard of the Monitoring UI showing a historical forecast and its validation data.

3.3.10.18 Relevant Documentation

There are no further relevant documents.

4 Conclusion

4.1 Summary of Achievements

The first iteration of the ScaleAgData demonstrators has successfully integrated, deployed, and evaluated a range of digital agricultural solutions across the six RILs. Through the combination of IoT sensors, EO-based monitoring, AI-driven analytics, and edge computing, the demonstrators have provided actionable insights for farmers, agronomists, and policymakers. Additionally, strong cross-WP collaborations and stakeholder engagement have played a crucial role in refining the demonstrators to ensure they address real-world agricultural challenges effectively.

Key achievements include:

- **Successful integration of sensor networks and EO data** to enhance crop monitoring, soil health assessment, and water productivity management, ensuring multi-source data fusion for improved decision-making.
- **Deployment of decision support systems (DSSs) tailored to regional agricultural needs**, improving precision farming and sustainability monitoring while fostering synergies between different RILs.
- **Development of AI-driven analytical models** to provide real-time insights, such as yield forecasting, pest detection, and nutrient management, supporting both farmers and policymakers with predictive capabilities.
- **Active stakeholder engagement and co-design processes**, involving farmers, advisors, and policymakers to ensure that the demonstrators align with user needs and can be effectively adopted in diverse agricultural settings.
- **Strengthened cross-RIL and cross-WP synergies**, where demonstrator insights and lessons learned contribute to iterative improvements in data-sharing frameworks, service scalability, and interoperability of digital solutions.
- **Preliminary evaluation of demonstrator impact**, tracking sustainability KPIs and user feedback to assess the effectiveness of digital farming tools and guide refinements for future iterations.

These achievements align with ScaleAgData's overarching goals of enhancing data-driven decision-making in agriculture, supporting sustainable farming practices, and providing policy-relevant insights. The first iteration has laid the foundation for further refinement, stakeholder-driven improvements, and upscaling of these solutions in the next phase.

4.2 Next Steps

Building on the insights gained from the first iteration, the next phase of the demonstrators will focus on further deployment, evaluation, and refinement to enhance their effectiveness and scalability. Key activities planned for the second iteration include:

- Expanding demonstrator deployment to cover new agricultural regions and broader biogeographical zones, ensuring wider applicability.

- Enhancing data integration methodologies, leveraging improved AI models and multi-source data fusion to increase the precision and usability of digital farming tools.
- Refining end-user applications based on feedback from the first iteration, optimizing user experience, functionality, and interoperability with existing farm management systems.
- Conducting a more extensive impact evaluation, incorporating updated KPIs and validation metrics.
- Strengthening cross-RIL collaboration, facilitating knowledge exchange and best practices sharing among different thematic areas.
- Supporting the adoption of developed products ensuring that outcomes contribute to strengthen both the competitiveness and sustainability of European agriculture.

The second iteration will further validate the scalability, effectiveness, and impact of ScaleAgData's solutions, ensuring they are robust, adaptable, and ready for broader adoption across European agriculture.

5 Annexes

5.1 Annex I: RIL Demonstration Documentation Template:

RILx Demonstrator Documentation – 1st Iteration

[x: Please enter the number of the RIL]

RIL Leader: [Please enter the organisation name and the name(s) of the contact person(s)]

RIL Partners: [Please enter the organisation name and the name(s) of the contact person(s)]

1. Demonstrator No. x.y

[x: Please enter the number of the RIL - y: Please enter the number of the RIL's demonstrator]

2. Demonstrator Overview

[Please add information about what the demonstrator such as the above:

Title of demonstrator:

Thematic focus of RIL's demonstrator:

Objective of the demonstrator: (What is the primary goal? What challenge does it address?)]

3. General Description

Brief Description

(100-150 words):[Please summarize the purpose and core components of the demonstrator.]

Technologies Used:

[Please list the technologies applied in the demonstrator, including information about collaborations with technical providers.]

4. Deployment Information

Deployment Timeline:

[Indicate the readiness level of the demonstrator and when the deployment is planned to be completed.]

Integration with Existing Systems:

[Describe how the demonstrator has been integrated with existing end-user applications. Mention any challenges faced or solutions used.]

Deployment Locations:

[Provide specific information on where the demonstrator has been deployed, including the type of site (e.g., farms, monitoring stations) and relevant geographical details (e.g. the administrative region where it is located).]

Map of Deployment Location(s):

[Attach or include a map that visually indicates the location(s) of the demonstrator. Highlight key geographical features or regions relevant to the demonstrator's function.]

5. End-users & Target Groups

Primary End-Users:

[Describe who the primary users of the demonstrator are, e.g., small-scale farmers, agricultural co-operatives, policymakers, research institutions, etc.]

Target Groups:

(Identify the broader target groups for the demonstrator, specifying any additional stakeholders that benefit from or interact with the demonstrator, e.g., agricultural consultants, environmental agencies, etc.)

User Needs and Expectations:

[Summarize the specific needs and expectations of the end-users that the demonstrator addresses. Include any challenges faced by these groups and how the demonstrator helps overcome them.]

6. Evaluation - Impact

Evaluation Objectives

(Describe the purpose of the evaluation, including what aspects of the demonstrator will be assessed (e.g., performance, usefulness, usability, impact, user satisfaction, alignment with goals)

Evaluation Approach:

(Describe the methods and tools that will be used for evaluating the demonstrator's impact and performance.)

Key Performance Indicators (KPIs):

(Please indicate the relevant KPIs for your demonstrator using the existing list of your Lab-specific KPIs.)

Foreseen Risks:

(Identify potential risks that could impact the demonstrator's performance and provide possible measures for the mitigation of these risks.)

Feedback from participants

(Please indicate the collected feedback)

7. Future Developments

Planned Improvements for 2nd Iteration:

(Describe any planned updates or changes for the next iteration based on evaluation feedback.)

Scalability and Replication:

(Explain how the demonstrator could be scaled or replicated in other regions or for other use cases.)

8. Supporting Materials

Images/Diagrams:

(Attach any visual aids, screenshots, or diagrams of the demonstrator and its deployment.)

9. Relevant Documentation:

(Link or attach any technical documentation, user manuals, or references to external resources.)

5.2 Annex II: Specific KPIs per RIL for impact evaluation:

Crop Management R&I Lab 2a				
KPI 1 Description: % increase / number of Advisors / policy makers/ farmers interest in using the data product				
Link to the Data Product and Services: Agri-environmental monitoring for policy makers				
Link to the Impact Dimension(Economic/social/Scientific): Socially. Economic: productivity increase in advisors/ better decision making				
Target Group/s: Advisors				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	3	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.
KPI 2 Description: % decrease in used				
Link to the Data Product and Services: Agri-environmental monitoring for policy makers				
Link to the Impact Dimension(Economic/social/Scientific): Social: , Food quality/ security and safety(Social); Less environmental pollution(water-Soil) (Social); Cost reduction(Economic/Tech); Increasing the farmer's income (Economic/Tech -Social)				
Target Group/s: farmers,				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%		Rating Scale (from 1 to 6):	Comments

		E.g. number/ per year; kg/ha...	<p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>XX5: favourable effect (Number/ %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Please shortly explain the reason of your choice.
KPI 3 Description: Increase in datasets for further scientific research				
Link to the Data Product and Services: Agri-environmental monitoring for policy makers				
Link to the Impact Dimension(Economic/social/Scientific): Scientific: Creation of datasets for further scientific research				
Target Group/s : Researchers, Tech Providers				
Data sources/ and measurement methods				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value		<input type="checkbox"/> judgements by experts/ Survey		
<input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value				
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>X5: favourable effect (Number/ %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>Please shortly explain the reason of your choice.</p>
KPI 4 Description: % Decrease in time for monitoring of the sustainability KPIs of the Common Agricultural Policy (CAP)				
Link to the Data Product and Services: Agri-environmental monitoring for policy makers				
Link to the Impact Dimension(Economic/social/Scientific): Social/economic: Reduce time; better work management, efficiency				
Target Group/s : Advisors				

Data sources/ and measurement methods				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		X judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.

Crop Management R&I Lab 2b				
KPI 1 Description: % increase / number of Advisors / policy makers/ farmers interest in using the data product				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Socially. Economic: productivity increase in advisors/ better decision making				
Target Group/s: Advisors/farmers				
Data sources/ and measurement methods				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
The baseline is set as historical data on the number of crop units created in the DSS in the Emilia-Romagna region in Italy	Increase by 5%	number / per year	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving	Comments

			<p>this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Please shortly explain the reason of your choice.</p>
KPI 2 Description: % decrease in used pesticides				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Social: , Food quality/ security and safety(Social); Less environmental pollution(water-Soil) (Social); Cost reduction(Economic/Tech); Increasing the farmer's income (Economic/Tech -Social)				
Target Group/s: farmers,				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<p>XHistorical Data from your Organisation / Compared to the baseline value</p> <p><input type="checkbox"/>Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value</p>			<p><input type="checkbox"/>judgements by experts/ Survey</p>	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
The baseline is set as historical data on the amount of plant protection products used in wheat crops	Decreased by 20%	kg/ha	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>Please shortly explain the reason of your choice.</p>
KPI 3 Description: number of treatments from field reports				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Social: Less pesticide usage; Food quality/ security and safety(Social); Less environmental pollution(water-Soil) (Social); Cost reduction(Economic/Tech); Increasing the farmer's income (Economic/Tech - Social)				
Target Group/s: Farmers/advisors				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				

XHistorical Data from your Organisation(from field reports) / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
The baseline is set as historical data on the amount number of plant protection products application in wheat crops	Decreased by 10%	number/ per year	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.
KPI 4 Description: % decrease in crop reduction/ % Increase in Yield per Hectare				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): economic,Social: improved food availability, increased farm profitability, and enhanced food security.				
Target Group/s : farmers , public				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
XHistorical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
The baseline is set as historical data on the yields in crop units managed by mean of the Decision Support System	Yield increased by 5%	t/ha	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact	Comments Please shortly explain the reason of your choice.

			<input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	
KPI 5 Description: increase in datasets for further scientific research				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Scientific: Creation of datasets for further scientific research				
Target Group/s : Researchers, Tech Providers				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		Xjudgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): 5 <u>Estimated value Assuming: data on 10 wheat parcels per cropping season</u> Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input checked="" type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments <u>Wheat parcels are being monitored in the frame of the project, allowing to collect data</u>
KPI 6 Description: % Decrease in travel time for inspection activities				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Social/economic: Reduce time; better work management, efficiency				
Target Group/s : Advisors/Framers				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Time dedicated by farmers to field visits in the	Decreased by 10%	hours/ per year	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)	Comments

field to inspect the crops (diseases, pests, weeds)			<p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>5: favourable effect (Number/ %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Please shortly explain the reason of your choice.
KPI 7 Description: % Decrease in time for monitoring of the sustainability KPIs of the Common Agricultural Policy (CAP)				
Link to the Data Product and Services: Decision Support System				
Link to the Impact Dimension(Economic/social/Scientific): Social/economic: Reduce time; better work management, efficiency				
Target Group/s : Advisors				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		Xjudgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	<p>Rating Scale (from 1 to 6): 5</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>5: favourable effect (Number/ %) <input checked="" type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>On the base for the data collected, and the farm log, the Decision Support System can automatically calculate different sustainability indicators</p>

Crop Management R&I Lab 2c				
KPI 1 Description: % increase / number of Advisors / policy makers/ farmers interest in using the data product				
Link to the Data Product and Services: DSS				
Link to the Impact Dimension (Economic/social/Scientific): Socially. Economic: productivity increase in advisors/ better decision making				
Target Group/s: Advisors				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> <input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description Currently there are 34 of advisors using the system in wielkopolska region. After providing the new feature new advisors are expected to be engaged. Advisors involved in process In wielkopolska: 34 Using data product: 0	Increased by 30%.	Number of users	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Advisors will be given a new toll to use, which will make them more efficient in work and this will translate into more targeted alerts/recommendations to farmers
KPI 2 Description: % decrease in used pesticides per hectare				
Link to the Data Product and Services: DSS				
Link to the Impact Dimension (Economic/social/Scientific): Social; Food quality/ security and safety (Social); Less environmental pollution(water-Soil) (Social); Cost reduction (Economic/Tech); Increasing the farmer's income (Economic/Tech -Social)				
Target Group/s: farmers,				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> <input checked="" type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	

<p>Baseline Description</p> <p>We want to measure the difference between the number of used pesticides before and after.</p>	<p>Decreased by 5%-10%.</p>	<p>Millilitres / gram per hectare</p>	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input checked="" type="checkbox"/>3: low influence (5-10%)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>On the basis of data obtained from observations and math models, farmers will be able to make better decisions on use of plant protection products</p>
<p>KPI 3 Description: number of treatments from field reports</p>				
<p>Link to the Data Product and Services: DSS</p>				
<p>Link to the Impact Dimension (Economic/social/Scientific): Social: Less pesticide usage; Food quality/ security and safety (Social); Less environmental pollution(water-Soil) (Social); Cost reduction (Economic/Tech); Increasing the farmer's income (Economic/Tech - Social)</p>				
<p>Target Group/s: Farmers/advisors</p>				
<p><i>Data sources/ and measurement methods</i></p>				
<p>Please Select the data sources and measurement methods and give a brief explanation of the reasons</p>				
<p><input checked="" type="checkbox"/> Historical Data from your Organisation (from field reports) / Compared to the baseline value</p> <p><input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value</p> <p><input type="checkbox"/> judgements by experts/ Survey</p>				
<p>Baseline value:</p>	<p>Target value</p>	<p>Measurement units</p>	<p>Measurement units/ Estimated Value</p>	
<p>Baseline Description</p> <p>We want to measure the decrease in number of treatments based on calculated probability of the pest occurrence.</p>	<p>Decreased by 20%.</p>	<p>number</p>	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving</p>	<p>Comments</p>

144217 treatments in year 2024 (each plant considered)			<p>this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Reducing the number of treatments performed will contribute to less impact on environmental pollution
KPI 4 Description: % decrease in crop reduction/ % Increase in Yield per Hectare				
Link to the Data Product and Services: DSS				
Link to the Impact Dimension (Economic/social/Scientific): economic, Social: improved food availability, increased farm profitability, and enhanced food security.				
Target Group/s: farmers, public				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value		<input type="checkbox"/> X judgements by experts / Survey		
<input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value				
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description Effective use of plant protection products will result in decrease in crop reduction	Decreased by 5%.	Kg/ha dt/ha	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input checked="" type="checkbox"/>3: low influence (5%)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Comments More targeted information to farmers should translate into better crop management and thus a decrease in crop reduction or increase in yield
KPI 5Description: % of pests detected (effectiveness)				
Link to the Data Product and Services: DSS				

Link to the Impact Dimension (Economic/social/Scientific): Economic: better efficiency of pest recognition				
Target Group/s : advisors				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description Increased effectiveness due to increased number of observations. Agrophages on wheat, sugar beet, corn: 442 – pest 394 - disease	Increased by 10-20%.	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Due to increased number of observation points of non-protected fields, it's expected to locate more pests.
KPI 6 Description: increase in datasets for further scientific research				
Link to the Data Product and Services: DSS				
Link to the Impact Dimension (Economic/social/Scientific): Scientific: Creation of datasets for further scientific research				
Target Group/s : Researchers, Tech Providers				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description Increase in data from field reports.	increase by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)	Comments More reports are expected, which will translate

<p>Pontantial for detection of pests previously unknown</p> <p>Reports per year on wheat, corn : 6000</p>			<p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>into larger datasets for analysis / scientific research</p>
<p>KPI 7 Description: number of/ % increase in alerts comparison to last years from observations and numerical models</p>				
<p>Link to the Data Product and Services: DSS</p>				
<p>Link to the Impact Dimension (Economic/social/Scientific): Social/economic: better crop management by farmers (more efficient pesticides control)</p>				
<p>Target Group/s : Farmers/advisors</p>				
<p><i>Data sources/ and measurement methods</i></p>				
<p><i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i></p>				
<p><input type="checkbox"/> <input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value</p> <p><input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value</p>		<p><input type="checkbox"/> judgements by experts/ Survey</p>		
<p>Baseline value:</p>	<p>Target value</p>	<p>Measurement units</p>	<p>Measurement units/ Estimated Value</p>	
<p>Baseline Description</p> <p>We want to measure the increase in recommendations based on the agrophage occurrence probability.</p> <p>Alerts from models: 13775</p> <p>Alerts from reports: 202567</p>	<p>Increased by 20%.</p>	<p>number</p>	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p>	<p>Comments</p> <p>More reports will translate into more alerts to farmers – which in turn will translate into better management in field</p>

				<input type="checkbox"/> 6: very favourable effect (Number/ %)	
KPI 8 Description: % Decrease in travel time for inspection activities					
Link to the Data Product and Services: DSS					
Link to the Impact Dimension (Economic/Social/Scientific): Social/economic: Reduce time; better work management, efficiency					
Target Group/s : Advisors					
<i>Data sources/ and measurement methods</i>					
Please Select the data sources and measurement methods and give a brief explanation of the reasons					
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value		
Baseline Description We want to measure the decrease in travel time regarding the inspections of the observation points. 31 096 km	Decreased by 20%	kilometres	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAg-Data data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.	

Yield Management R&I Lab					
KPI 1 Description: number of advisors or farmers interested in using the yield maps for evaluation of management practices, post-harvest and /or for diagnosis of yield variations across years					
Link to the Data Product and Services: yield maps (sub-field level)					
Link to the Impact Dimension (Economic/Social/Scientific): Social. Economic: better decision making for climate; increased production					
Target Group/s: Advisors/ farmers					
<i>Data sources/ and measurement methods</i>					
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value		

Number of workshop participants: 20/event (e.g. users at ScaleAg-Data demonstration events, stakeholder events or other (external) outreach/promotion events...)	Number of workshop participants interested in using the product: 5/event	number	<p>Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>5: favourable effect (Number/ %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Comments Please shortly explain the reason of your choice.
KPI 2 Description: Decrease in (chemical) fertilizer use				
Link to the Data Product and Services: N uptake maps & yield maps (sub-field level)				
Link to the Impact Dimension (Economic/Social/Scientific): Environmental pollution (water-soil) (Social); Cost reduction (Economic/Tech); Increasing the farmer's income (Economic/Tech, Social); better decision making for climate (Social)				
Target Group/s: Farmers/advisors				
<i>Data sources/ and measurement methods</i>				
<input type="checkbox"/> Historical Data from your Organisation (from field reports) / Compared to the baseline value		X judgements by experts/ Survey		
<input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value				
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	<p>Rating Scale (from 1 to 6): <u>Estimated value</u> <input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input checked="" type="checkbox"/>5: favourable effect (5 %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	Comments It assumes that ScaleAgData services for generating yield and N uptake maps are available to farmers and that these maps are used as input for variable rate fertilization, which could lead to a lower use of fertilizers (lower amount of fertilizer used and hence lower costs).
KPI 3 Description: Creation of methods and datasets for yield monitoring at different scales, for demonstration to potential users/stakeholders, or for further scientific research and product development				
Link to the Data Product and Services: methods and/or demo products developed in ScaleAgData				

Link to the Impact Dimension (Economic/Social/Scientific): Economic/Social/Scientific: Creation of demonstration products for farmers who currently don't have access to yield information, for improved decision-making (Economic; Social); Creation of demonstration products for potential customers/users such as agricultural service providers, machinery producers, insurance companies or public authorities that could benefit from these products to improve their current products/services (Economic, Social); Creation of methods and datasets for further scientific research; contribution to scientific advancements, technological development, and enhanced research capabilities (Scientific).			
Target Group/s: Researchers, Tech Providers			
<i>Data sources/ and measurement methods</i>			
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value
(new methods / products)	Methods: 2 Creation of demo products: 2 types of products; for 5 regions; for 4 types of users	Number	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)
KPI 4 Description: Number of agricultural service providers / machinery producers / insurance companies / public authorities interested in adopting the developed services			
Link to the Data Product and Services: service for yield estimation (digital twin or ML based), service for tare estimation in potatoes			
Link to the Impact Dimension (Economic/Social/Scientific): Social/Economic/Scientific. Agri service providers: access to yield or N uptake maps to offer to their customers/farmers (e.g. via FMIS), save on own developments (Economic, Social); seed breeders, agri researchers: increased efficiency - access to yield maps as input for trial field selection and design or to measure trial outcome (Economic, Scientific); machinery producers: product improvement - access to EO/model based yield estimates to create gap-filled or tare-corrected yield maps for their customers (Economic, Social); insurance companies: increased efficiency - access to yield estimates for loss adjustment (Economic); public authorities: access to another source of yield estimates for production/food security monitoring (Social)			
Target Group/s: agribusiness, insurance sector, public sector			
<i>Data sources/ and measurement methods</i>			
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value

(0: new services)	Agri service providers: 2 Machinery producers: 2 Insurance companies: 2 Public authorities: 1	number	<p>Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p>Estimated value (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact <input type="checkbox"/>2: no influence <input type="checkbox"/>3: low influence (Number/ %) <input type="checkbox"/>4: uncertainty concerning the impact <input type="checkbox"/>5: favourable effect (Number/ %) <input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>Please shortly explain the reason of your choice.</p>
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Soil Heath R&I Lab				
KPI 1 Description: : % Increase in biodiversity in farmland				
Link to the Data Product and Services: SOC maps, SOC health monitoring				
Link to the Impact Dimension(Economic/social/Scientific): : (Social); Less Soil/ Land degradation (Social)				
Target Group/s: Farmers				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	<p>Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p>Estimated value (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p>	<p>Comments</p> <p>Provided soil data, such as organic carbon (OC), gives farmers the opportunity to monitor soil conditions, which can help improve soil quality, enhance crop growth, and increase biodiversity. However,</p>

			<input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input checked="" type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	the impact is indirect and difficult to quantify.
KPI 2 Description: % Increase in number of datasets/ publications to support the development of technologies				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Scientific /Social: Creation of datasets for further scientific research; Knowledge transfer; support on development of similar data product				
Target Group/s: Farmers, researchers, AgriTech companies				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (With ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input checked="" type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments The methodology to generate the SOC models and generate SOC maps with Federated Learning has been demonstrated during an online webinar. In addition, it has been written up as a conference paper and submitted for the conference. AUTH have published a conference paper in
KPI Description: : Number of policy makers/farmer/researchers reached and informed for federated learning, soil carbon maps, models, or databases developed				
Link to the Data Product and Services: Soil Health monitoring tool , federated learning				
Link to the Impact Dimension(Economic/social/Scientific): Social: Provide better insight regarding Carbon stocks in soil, to the policy makers, farmers, public, scientist (Social); improve awareness, knowledge, / Knowledge transfer (Economic/Tech; Social); Support new soil maintaining laws				
Target Group/s: public , policy makers, farmers , researchers, agritech companies				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				

<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description We have feedback 25 feedback	25	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (With ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.
KPI Description: % Decrease in chemical fertiliser use				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Economic, social: reduce costs, Increase farmers revenue,				
Target Group/s : farmers				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input checked="" type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description contribution to scientific advancements, technological development, and enhanced research capabilities.	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (With ScaleAgData data products and services ready for use, assess how their implementation could support	Comments

			<p>achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Provided soil health monitoring data, such as organic carbon (OC), enables farmers to make informed decisions to improve soil health and reduce reliance on chemical fertilizers. While the impact is indirect and difficult to quantify, awareness of the negative effects of chemical fertilizers may lead farmers to adjust their fertilization strategies.</p>
KPI Description: : % Increase in the soil organic matter				
Link to the Data Product and Services: SOC, soil health monitoring product				
Link to the Impact Dimension(Economic/social/Scientific): Lower emissions (Social); Less Soil/ Land degradation (Social)				
Target Group/s : Farmers				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input checked="" type="checkbox"/> Judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	<p>Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (With ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>Informing farmers about SOC can encourage them to improve OC when levels are low, but the impact is indirect and difficult to measure</p>

KPI Description: : % Increase in the use of environmental friendly agricultural practices (no-till farming, agroforestry, crop rotation)				
Link to the Data Product and Services: SOC, soil health monitoring product				
Link to the Impact Dimension(Economic/social/Scientific): Environmental pollution(water-Soil) (Social); Less Soil/ Land degradation (Social)				
Target Group/s : farmers				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input checked="" type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (With ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> XX5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Provided soil data, such as organic carbon (OC), gives farmers the opportunity to improve soil quality and adopt environmentally friendly practices. However, the impact is indirect and difficult to quantify.

Grassland R&I Lab	
KPI 1 Description: Number of young people engaged in learning about modern agricultural technologies or participating in specialized training programs.	
Link to the Data Product and Services: Mediterranean grasslands productivity in a changing environment	
Link to the Impact Dimension (Economic/social/Scientific): Socially/ Economic: Enhancing rural economies by creating sustainable employment, with advancing agricultural innovation, encouraging young people to become farmers, and supporting unemployment reduction through agricultural opportunities.	
Target Group/s: Farmers	
<i>Data sources/ and measurement methods</i>	
IFAPA regularly organizes courses to support the installation of young farmers, new farmers and rural business, with the aim to contribute to the generational renewal. The technologies and services developed by the grassland lab will be presented in those courses for ranchers. Measurement method: number of young farmers engaged in specialized training including learning material developed by ScaleAgData.	
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data / Compared to baseline (standard) value	<input type="checkbox"/> judgements by experts/ Survey

Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
The current training programs for young farmers do not incorporate sensors and remote sensing in grazing and grassland management decisions. The development of the Grassland Lab will be integrated into the courses of the following years.	Increased by 15-30/ per year (1-2 courses per year;	Number of young farmers trained per year	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (10 farmers) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (30-50 farmers) <input type="checkbox"/> 6: very favourable effect (>50 farmers)	Comments Please shortly explain the reason of your choice.
KPI 2 Description: Number of participants in project workshops and demonstrations				
Link to the Data Product and Services: Mediterranean grasslands productivity in a changing environment				
Link to the Impact Dimension(Economic/social/Scientific): Economic/social Expanding awareness and adoption of new agricultural tools, enhancing productivity and efficiency in the sector.				
Target Group/s: Farmers, cooperative staff, policy makers, researchers				
<i>Data sources/ and measurement methods</i>				
Measured number of participants in activities and number of answers to the questionnaires design by the Lab				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	20	number of participants	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (10) <input type="checkbox"/> 4: uncertainty concerning the impact	Comments Please shortly explain the reason of your choice.

			<input checked="" type="checkbox"/> 5: favourable effect (>20) <input type="checkbox"/> 6: very favourable effect (>50)	
KPI 3 Description: Number of stakeholders reached/ informed with newly developed products and services.				
Link to the Data Product and Services: Mediterranean grasslands productivity in a changing environment				
Link to the Impact Dimension(Economic/social/Scientific): Economic/social Enhancing agricultural sustainability and drought resilience by providing farmers with essential growth and climate-related information and tools.				
Target Group/s: farmers				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	30	Number of stakeholders reached	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (20-50) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (>50) <input type="checkbox"/> 6: very favourable effect (>100)	Comments Please shortly explain the reason of your choice.
KPI Description: Number of farmers and/or insurance companies utilizing drought indices for risk assessment and decision-making *EURAC has provided KPIs in a different folder and format				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Economic/social Enhancing economic stability for farmers and productivity for insurance companies ; Strengthening drought resilience for grassland by providing affordable drought indices that help farmers mitigate financial risks and assist insurance companies in assessing risk for drought-related claims.				
Target Group/s : Farmers, Insurance companies				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				

<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description contribution to scientific advancements, technological development, and enhanced research capabilities.	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.
KPI Description: % Decrease in number of farmer declaration mistakes *EURAC has provided KPIs in a different folder and format				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Improve the objectivity- transparency and reliability of the inspections (Economic/ Social); Increasing the farmer's income(Economic/-Social)				
Target Group/s : Farmers, insurance companies/ inspectors				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact	Comments Please shortly explain the reason of your choice.

			<input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	
KPI Description: Number of policymakers and public authorities reached and/or provide positive feedback *EURAC has provided KPIs in a different folder and format				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Strengthening drought resilience by providing policymakers and public authorities with data-driven insights to enhance planning (hydrological and drought management planning) and decision-making.				
Target Group/s : Policy makers, public authorities				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				
<input type="checkbox"/> Historical Data from your Organisation / Compared to the base-line value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	Decreased by...%	E.g. number/ per year; kg/ha...	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments Please shortly explain the reason of your choice.
KPI 4 Description: Number of scientific and methodological publications in relation with the productivity of grasslands				
Link to the Data Product and Services: Mediterranean grasslands productivity in a changing environment				
Link to the Impact Dimension(Economic/social/Scientific): improve awareness, knowledge, digital technologies in agricultural risk management / Knowledge transfer (Social).				
Target Group/s : Policy makers, public authorities				
<i>Data sources/ and measurement methods</i>				
<i>Please Select the data sources and measurement methods and give a brief explanation of the reasons</i>				

<input type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value			<input type="checkbox"/> judgements by experts/ Survey	
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Baseline Description	3	number of publication	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, (considering current result of the products) ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (1) <input type="checkbox"/> 4: uncertainty concerning the impact <input type="checkbox"/> 5: favourable effect (2) <input type="checkbox"/> 6: very favourable effect (>3)	Comments Please shortly explain the reason of your choice. Please shortly explain the reason of your choice.

KPI list and monitoring

Demonstrator: Monitoring the productivity of mountain grasslands.

Scientific KPIs:

SECTOR	INDICATOR	METHOD OF MEASUREMENT	TARGET GROUP	PROJECT START	1 st ITERATION	2 nd ITERATION (expectation and planned actions)

Social	Transparency in Indemnity Calculation: This KPI evaluates the transparency in calculating indemnities using satellite data.	This can be measured by evaluating the clarity and accessibility of the methods used to calculate indemnities. Surveys and feedback from stakeholders can be used to assess their understanding and satisfaction with the process	Farmers and their consortia	Low Previous system based on sparse local meteorological stations, without correspondence with actual losses.	Moderate Based on drought indices whose correlation with yield has been assessed against in situ measurements.	High Organize additional seminars to better the methods used to calculate yield losses.
	Stakeholder Engagement: This KPI assesses the involvement of key stakeholders in the implementation process.	This can be measured by tracking the number of stakeholders involved in the implementation process, their level of participation in meetings and workshops, and their feedback on the process and trust in the proposed methodologies.	Consortia of farmers and local authorities.	1 consortium 1 local authority. Level of participation: high. Highly interested in the product and engaged in discussions for their improvement. Level of trust in the proposed technology: moderate. Preliminary discussion and tests.	1 consortium 1 local authority. Level of participation: high. Highly interested in the product and engaged in discussions for their improvement. Level of trust in the proposed technology: moderate.	1 consortium 1 local authority. Maintain high interest, increase trust, and do not increase number of stakeholders (we are a research institution. While supporting local stakeholders is part of our mission, we do not want to compete with players on a larger scale).
	Community and Farmer Engagement: This KPI measures the methods used to	This can be measured by the number of workshops and seminars con-	Farmers and their consortia	4 farmers participated	>100 farms insured by the co-developed parametric scheme.	>100 farms insured by the co-de-

	engage local communities and farmers regarding the benefits of satellite-based insurance.	ducted, the number of participants , and their feedback on the usefulness of the information provided		in preliminary tests.	2 seminars with local farmers consortium.	veloped parametric scheme. Increase farmers' understanding of how satellite data can support their activities. Organize a seminar directly addressing the farmers.
Economic	Cost Reduction: This KPI examines the reduction in insurance costs attributed to utilizing satellite data.	This can be measured by comparing the insurance costs before and after the implementation of satellite data. The percentage reduction in costs can be used as an indicator	Farmers and their consortia	Moderate	Moderate. The cost of a parametric insurance is much lower than the cost of physical checks by insurance appraisers. Data processing is still expensive because it still requires a significant amount of "manual" work.	To be automatized as much as possible to reduce the costs for generating the data.
Scientific	Accuracy of Damage Assessment: This KPI measures the accuracy of satellite data in assessing damage to alpine meadows.	This can be measured by comparing satellite data assessments with ground truth data. The percentage of accurate assessments can be used as an indicator	Farmers and their consortia. Scientific community.	Available data not sufficient for a robust validation.	Accuracy of Satellite-based LAI: Year 2023, 184 measurement points: r^2 : 0.62 RMSE: 1.82 MBD_-1.25 Year 2024, 168 measurement points: r^2 : 0.78 RMSE: 1.5 MBD: -1.14	Refine the validation study including all the available data. Do not reduce significantly the accuracy after having implemented ScaleAg-Data gap-filling methods.
	Availability of in situ data suitable for the validation of satellite	This can be directly measured by the number of monitored fields and of variables	Researchers, Insurance	Available data not	Monitored fields: Eight fields, monitored every two weeks from April to October, covering the	Data openly available upon publication.

	lite-based biophysical parameters	available for the validation of satellite-based products, and by their level of accessibility.	companies, Farmers and their associations	sufficient for a robust validation.	full growing season of the years 2023 and 2024. Variables: three main biophysical parameters (LAI, fAPAR, and yield) plus additional ancillary data. Accessibility: only within the Lab	
	Contribute to capacity building on the use of big-data for agricultural monitoring	Measured by the number of researchers engaged in tutorials and short courses during scientific conferences.	Researchers		Planned actions: EURAC plans to co-organize one or two learning sessions during a scientific conference (ESA Living Planet Symposium and/or IGARSS 2025).	EURAC will report here the training sessions and the number of attendees.

Dairy R&I Lab				
KPI 1 Description: 100% improved forecast availability of milk quality data for milk processing/ relevant data collected and integrated into forecasting systems and planning.				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Economic: , productivity, supply chain efficiency, and market competitiveness while reducing financial risks; Scientific: advances research in precision farming, sustainability, and AI-driven dairy analytics				
Target Group/s: Dairy cooperative				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input checked="" type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Only quantity is currently forecasted, no quality.	Forecast of quality for about 15 days	Amount of Fat/ kg of milk Amount of Proteine/ kg of milk	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)	Comments The forecast of milk quality parameters was not done before and having no related tools. Only by ScaleAg-Data, the approach seems

			<p>Based on your knowledge and experience, ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input checked="" type="checkbox"/>6: very favourable effect (Number/ %)</p>	feasible to provide daily forecasting.
KPI 2 Description: 5 % reduction in the security margin required for sales planning;				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Economic:. Lower costs, waste and better efficiency				
Target Group/s: Dairy cooperative				
<i>Data sources/ and measurement methods</i>				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value		<input checked="" type="checkbox"/> judgements by experts/ Survey		
<input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value				
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Security margin in the rough planning when balancing input milk and dairy product output from production plants	Decreased by 5%	Liter of milk or kg of fat/day	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p><u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input checked="" type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>Any milk not used in a certain period will be processed to milk powder, requiring relatively large energy amounts and cannot being sold a fresh premium product for retailers and the B2C market, but for B2B</p>
KPI 3 Description: 50 % reduction of additional milk transport between the production facilities, due to missing forecasts of amounts of fat or protein, for serving the defined production programme.				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): reduce costs, increase profitability, and improve financial planning/ Cost reduction for transport, reduction of CO2 emissions				
Target Group/s : Dairy cooperative				

Data sources/ and measurement methods				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input checked="" type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	
Cost reduction for transport, reduction of CO2 emissions	Decreased by 50%	KM of additional milk transport	Rating Scale (from 1 to 6): Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20) <u>Estimated value</u> (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.) Based on your knowledge and experience, ScaleAgData data product and services potential contribution; <input type="checkbox"/> 1: negative impact <input type="checkbox"/> 2: no influence <input type="checkbox"/> 3: low influence (Number/ %) <input type="checkbox"/> 4: uncertainty concerning the impact <input checked="" type="checkbox"/> 5: favourable effect (Number/ %) <input type="checkbox"/> 6: very favourable effect (Number/ %)	Comments The transport planning is currently based on the location of farms in relation to the production facilities. This asks for additional transport between production facilities in case of deviations. The forecasting will allow for a better planning and reduce the additional transport of milk.
KPI 4 Description: 5% reduction in costs associated with batch changes in production facilities due to optimized planning.				
Link to the Data Product and Services:				
Link to the Impact Dimension(Economic/social/Scientific): Scientific : reduce costs, increase profitability, and improve financial planning/ Cost reduction for cleaning and reduction of production downtimes				
Target Group/s : Researchers, Tech Providers				
Data sources/ and measurement methods				
Please Select the data sources and measurement methods and give a brief explanation of the reasons				
<input checked="" type="checkbox"/> Historical Data from your Organisation / Compared to the baseline value <input type="checkbox"/> Generic Historical Data (Please indicate your data source) / Compared to baseline (standard) value		<input checked="" type="checkbox"/> judgements by experts/ Survey		
Baseline value:	Target value	Measurement units	Measurement units/ Estimated Value	

<p>Cost reduction for cleaning and reduction of production downtimes</p>	<p>Decreased by 5%</p>	<p>Overhead costs/ kg of product</p> <p>Cleaning time/ day</p> <p>Production Down-time/ day</p>	<p>Rating Scale (from 1 to 6):</p> <p>Please indicate the value per each scale (E.g. low influence: Decrease between %5-%20)</p> <p>Estimated value (Assuming ScaleAgData data products and services ready for use, assess how their implementation could support achieving this indicator and improving related outcomes/impact.)</p> <p>Based on your knowledge and experience, ScaleAgData data product and services potential contribution;</p> <p><input type="checkbox"/>1: negative impact</p> <p><input type="checkbox"/>2: no influence</p> <p><input type="checkbox"/>3: low influence (Number/ %)</p> <p><input checked="" type="checkbox"/>4: uncertainty concerning the impact</p> <p><input type="checkbox"/>5: favourable effect (Number/ %)</p> <p><input type="checkbox"/>6: very favourable effect (Number/ %)</p>	<p>Comments</p> <p>It is currently estimated to achieve an advancement. However, it might not result in this impact, since currently, the production is prioritising the production planning and control, enabled by higher security margins of available milk (i.e. available amounts of fat & proteine).</p>
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5.3 Annex III: Evaluation of usefulness and usability

Questions for Stakeholders on Satellite Data-Based Insurance for Mountain Meadows

• Introduction

• The following questions, formulated by Eurac Research, aim to gather information and address the challenges regarding the implementation and effectiveness of a parametric insurance policy to insure alpine meadows against yield losses due to drought events. The questionnaire is addressed to the main stakeholder, namely the Hagelschutzkonsortium - Condifesa di Bolzano.

• General Questions

1. What are your main expectations regarding satellite-based insurance for meadows?

• (Multiple choice – select up to 3 options)

- **Greater accuracy in damage assessment**
- **Faster claims handling**
- Reduction of insurance costs
- **More transparency in the calculation of compensation**
- **Access to reliable data for risk management**
- Better customization of policies
- Other (specify: _____)
-

2. What are the main benefits you foresee in using satellite data for meadow insurance?

• (Agreement scale response – from 1 to 5: 1 = not important at all, 5 = very important)

- Greater objectivity in damage assessment 1 2 3 4 5 555
- Reduction in reimbursement times 1 2 3 4 5 322
- Continuous monitoring of meadow status 1 2 3 4 5 254
- Less need for on-site surveys 1 2 3 4 5 542
- Other (specify: _____) 1 2 3 4 5
-

3. What potential challenges do you foresee in adopting this technology?

• (Multiple choice – Select up to 3 options)

- **High implementation cost**
- **Reliability and accuracy of measurements**
- Complexity in integrating with existing insurance systems
- Concerns about privacy and data management

- **Lack of familiarity with the use of satellite data in agriculture**
- Other (specify: _____)

• Technical Aspects

4. How do you evaluate the accuracy of satellite data in monitoring meadow conditions?

• (Multiple choice)

- Excellent, very reliable
- **Good, but with some room for improvement**
- **Acceptable, but not always precise**
- Poor, often inaccurate

5. Are you interested in improving data accuracy by using Sentinel-1 SAR data?

• (Multiple choice)

- **Yes**
- No
- I don't know

6. How important is it for you to estimate the absolute yield value rather than the forage production index?

• (Multiple choice)

- Very important
- **Quite important**
- Slightly important
- Not important

• Implementation and Use

7. What steps need to be taken to integrate satellite data into existing insurance models?

• (Multiple choice – select up to 3 options)

- Train staff on the use and interpretation of data
- **Ensure data compatibility with existing regulations**
- **Test the reliability and accuracy of satellite data**
- **Simplify data access for insurance operators**
- Other (specify: _____)

8. What measures should be in place to ensure data transparency and reliability?

• (Multiple choice – select up to 3 options)

- **Creation of clear standards for data collection and processing**
- **Provision of detailed reports on the methodologies used**
- **Continuous monitoring of data reliability through periodic checks**
- Other (specify: _____)

9. Are there specific regulatory considerations that need to be addressed for the adoption of satellite-based insurance?

- No
- Yes (specify: __allegato 4 PGRA (Piano Gestione Rischi Agricoltura)_)

• Economic Considerations

10. How do you evaluate the cost-effectiveness of using satellite data for meadow insurance?

- (Multiple choice)
- Very advantageous, benefits outweigh costs
- **Quite advantageous, but with some additional costs to consider**
- **Neutral, costs and benefits are balanced**
- **Slightly advantageous, costs are too high compared to benefits**
- Not advantageous at all

11. What pricing models are currently in use for insurance premiums?

- (Multiple choice – select up to 3 options)
- Prices based on actual risk determined by satellite data
- **Fixed annual prices for all beneficiaries**
- Variable pricing models based on seasonal or climatic conditions
- Differentiated premiums based on the size and type of meadows
- Discount for adopting advanced monitoring technologies (e.g., satellite)
- **Other (specify: _prices differentiated by municipality based on risk level)**

12. Are there financial incentives or subsidies supporting the adoption of this technology?

- No
- **Yes (specify: 50% premium contribution)**

• Stakeholder Involvement

13. Who are the key stakeholders that should be involved in the implementation process?

- **Insurance entities**
- **Farmers and landowners**
- Industry associations and agricultural consortia
- Research institutes and specialized universities
- Other (specify: _____)

14. How do you intend to engage local communities and farmers regarding the benefits of satellite-based insurance?

- (Multiple choice – select up to 3 options)
- **Organizing workshops and informative seminars**
- **Offering incentives for the adoption of satellite technology**
- **Providing concrete examples of how satellite data can improve insurance**
- Developing specific training programs for farmers
- Other (specify: sector events, such as AgriAlp)

• Future Perspectives

15. What advances in satellite technology do you foresee could improve meadow insurance?

• (Multiple choice – select up to 3 options)

- **Higher spatial resolution for more precise meadow condition analysis**
- **Improved analysis algorithms for more accurate damage assessments**
- **Use of other sensors (e.g., SAR radar) to increase temporal resolution**
- **Greater integration with other data sources (e.g., meteorological, agronomic)**
- Other (specify: _____)
-

16. How do you see the role of satellite data evolving in the broader context of agricultural insurance?

• (Multiple choice – select up to 3 options)

- Satellite data will become the main source of information for risk assessment
- **They will be integrated with other technologies (e.g., field sensors) for a more comprehensive view**
- **They will help develop more customized policies based on the specific needs of farms**
- **They will simplify the claims process and claims management**
- **They will increase the adoption of insurance among small and medium-sized agricultural enterprises**
- They will not have a central role, remaining a support to traditional techniques
- Other (specify: _____)
-
-

17. What are your long-term goals for the use of satellite data in meadow management and insurance?

• (Multiple choice – select up to 3 options)

- **Optimize risk assessment and insurance policy management**
- **Improve accuracy in damage estimation and compensation**
- Implement a continuous monitoring system for timely interventions
- Reduce operational costs through the use of satellite data
- Other (specify: _____)
-

18. How do you plan to measure the success and impact of satellite-based meadow insurance?

• Specify: ___feedback soci assicurati_____

• Evaluation of the First Version of Data

19. How do you rate the quality of the satellite data provided so far?

• (Multiple choice)

- Excellent, the data is extremely reliable and accurate
- **Good, the data is generally reliable with occasional margins of error**
- **Acceptable, but there are some areas where quality could be improved**

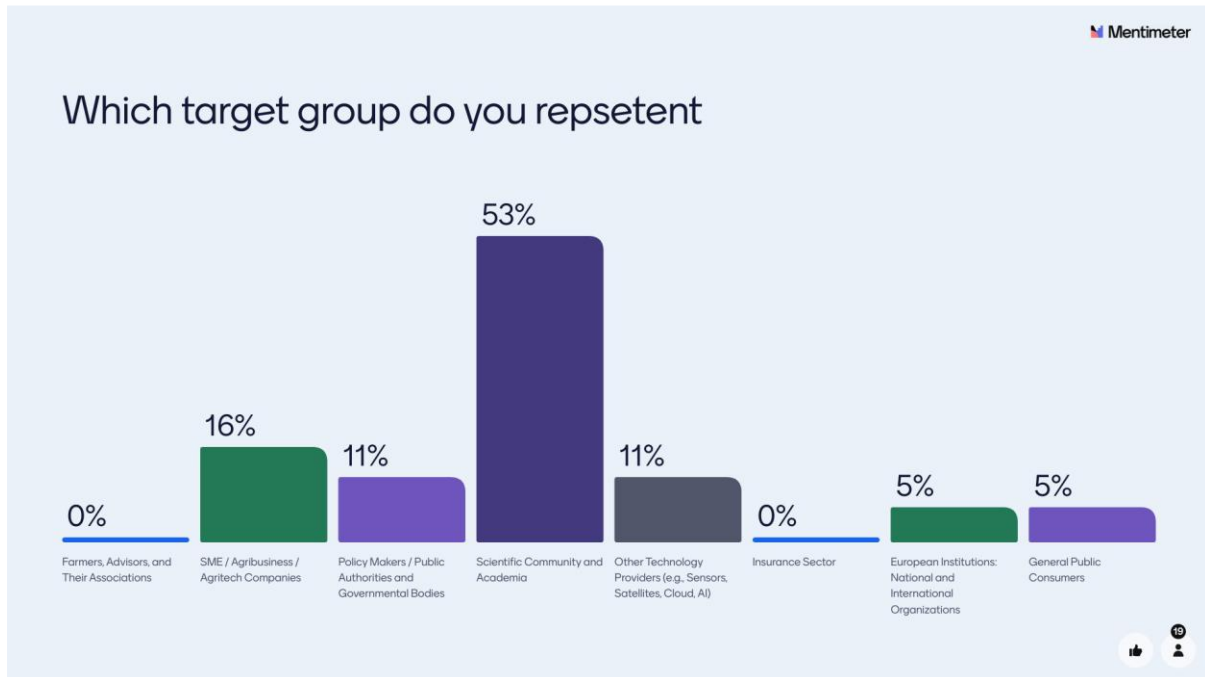
- **Poor, the data often presents inaccuracies and reliability issues**
 - I don't know
 -
20. What improvements would you suggest to increase the accuracy and reliability of the data?
- (Multiple choice – select up to 3 options)
- **Improve the spatial resolution of the data for greater precision**
 - **Increase the frequency of data updates for a more timely view**
 - Integrate satellite data with other data sources, such as field or meteorological sensors
 - **Implement more advanced analysis algorithms to improve data interpretation**
 - Use SAR (Synthetic Aperture Radar) technologies to monitor under difficult conditions (e.g., clouds)
 - Other (specify: _____)
 -
21. Have you encountered difficulties in interpreting the data provided?
- (Multiple choice)
- Yes, it is often difficult to understand and analyze the data
 - **Sometimes, there are some difficulties but they are manageable**
 - **Rarely, most of the data is easy to interpret**
 - No, we have not had any difficulty interpreting the data
 - I don't know
 -
22. How can we improve the presentation and accessibility of satellite data?
- (Multiple choice – select up to 3 options)
- **Offering tutorials and educational resources to facilitate data interpretation**
 - **Increasing transparency regarding the origin and methodology of the data**
 - **Providing real-time data or frequent updates**
 - **Creating visual reports (e.g., maps, charts) for immediate understanding**
 - Other (specify: _____)
 -
23. Are there specific data or metrics that you find missing or insufficient in the current version?
- No
 - **Yes (specify: define a calculation procedure for reference data for plots not suitable for calculating the index due to size or changes in land use)**

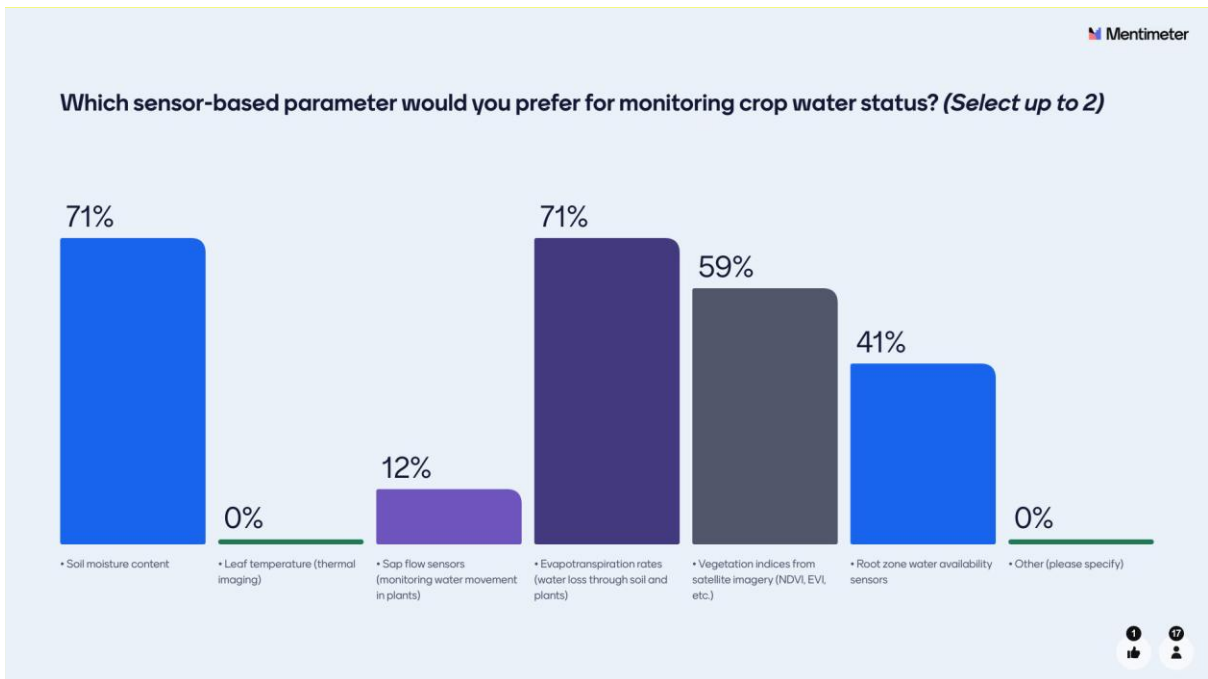
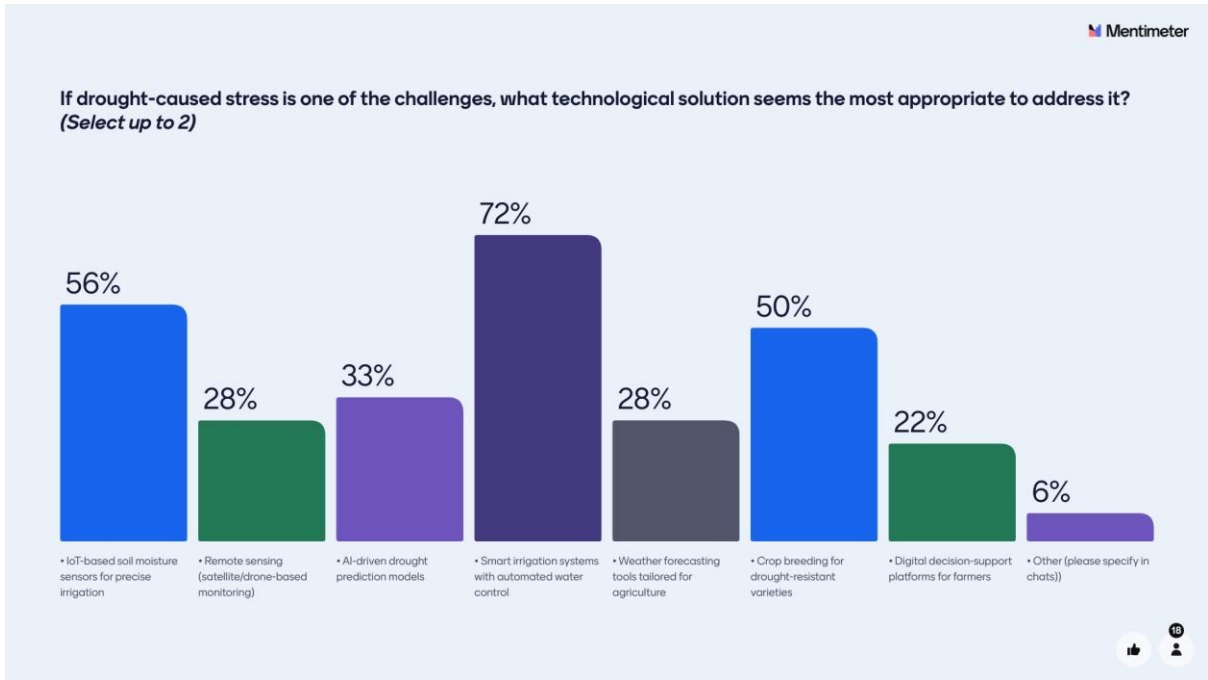
• Conclusion

- These questions are intended to guide discussions and gather valuable information from stakeholders. The answers will help shape the development and implementation of a robust and effective satellite data-based meadow insurance system.

5.4 Annex IV: Mentimeter Results

5.4.1 RIL1 Water RIL Mentimeter

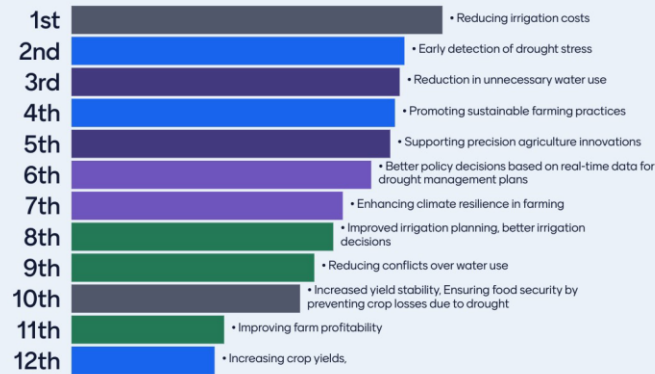




How do you see this service being most useful?

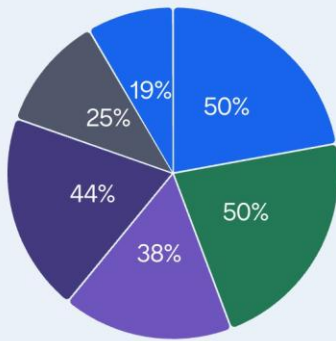


what are the most important benefits of this service for your work:



Mentimeter

What are the biggest challenges in using this service?

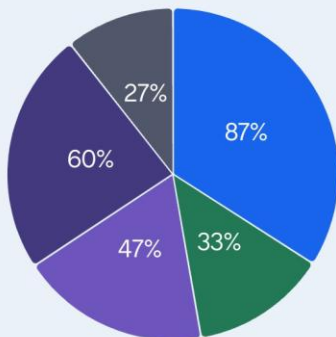


- 50% • Understanding and interpreting the data
- 50% • Technical issues with system integration (e.g., farm management tools, irrigation systems)
- 38% • Connectivity issues (poor internet access in rural areas)
- 44% • Lack of training or experience with digital tools
- 25% • Limited compatibility with different farm sizes and types
- 19% • Data privacy and security concerns



Mentimeter

What challenges do you see in using this service across different geographic locations?

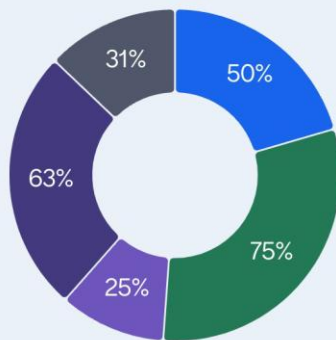


- 87% • Climate and soil variations affecting prediction accuracy
- 33% • Differences in local regulations and data-sharing policies
- 47% • Limited access to localized satellite and weather data
- 60% • Unequal access to technology in different regions
- 27% • High cost of necessary sensors and infrastructure



Mentimeter

What would improve the usability of this service the most?

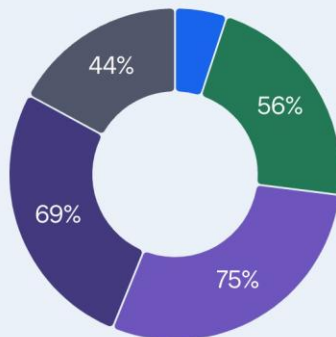


- 50% • A mobile-friendly app for real-time alerts
- 75% • Integration with existing farm management systems
- 25% • More visual and simplified reports
- 63% • Automated recommendations for farmers and policymakers
- 31% • Support for multiple languages



Mentimeter

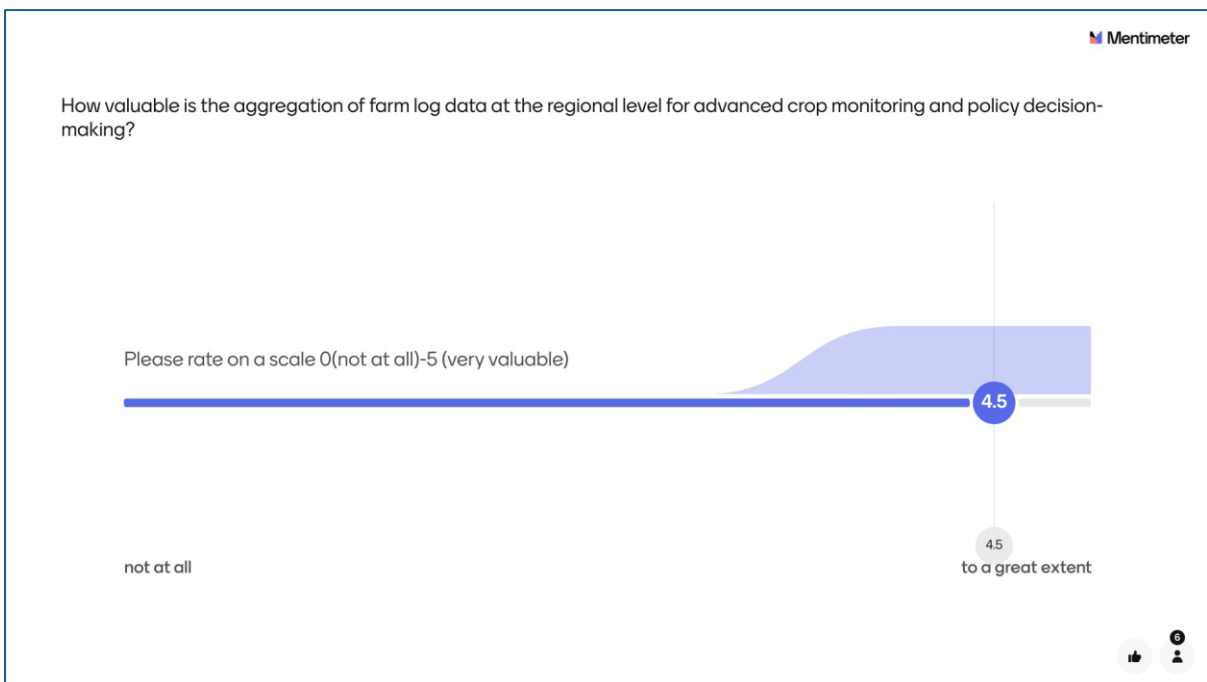
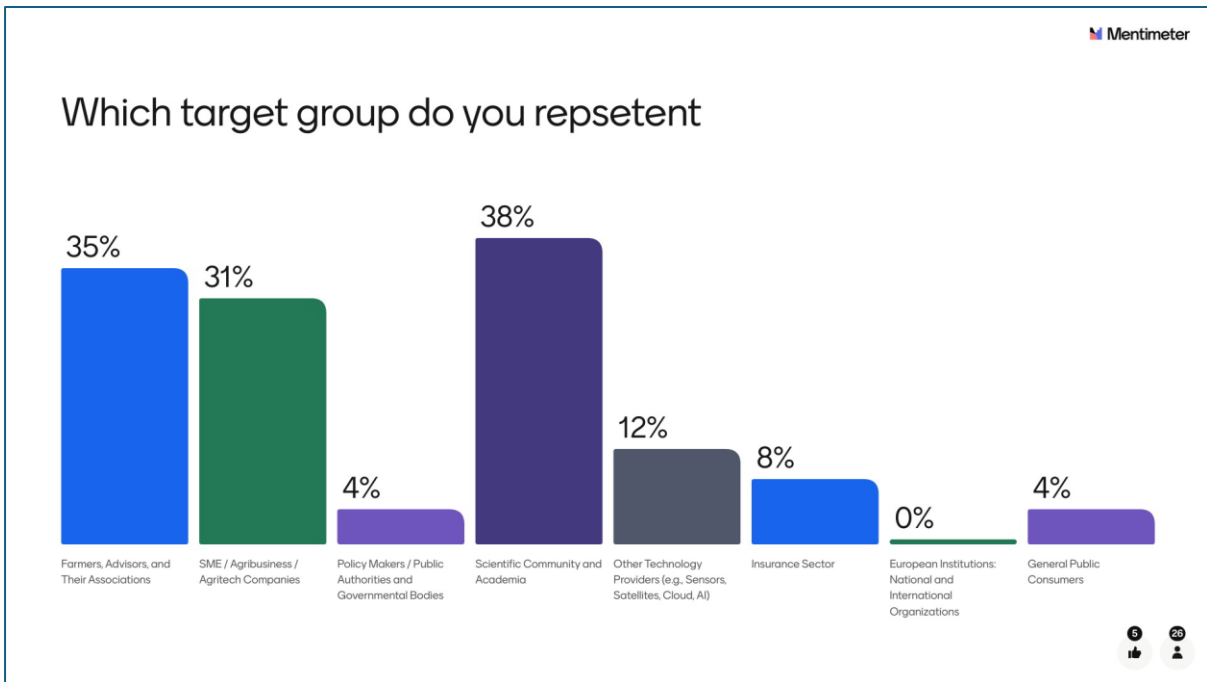
What would make this service more adaptable to different geographic locations

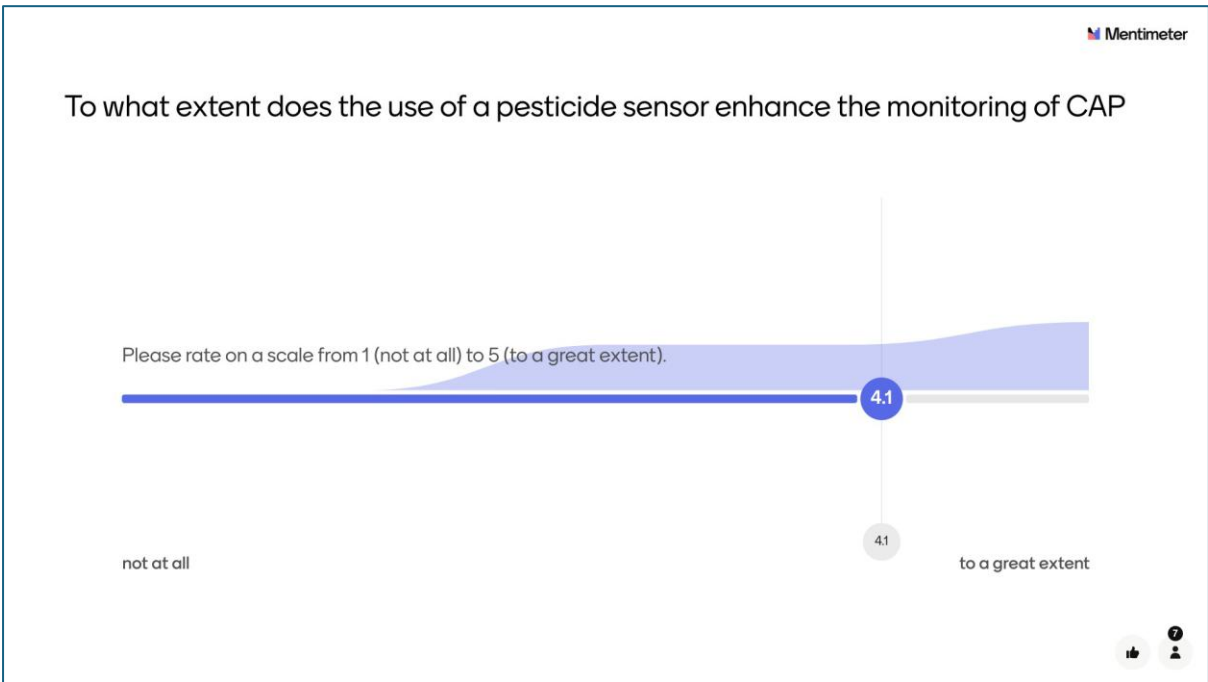
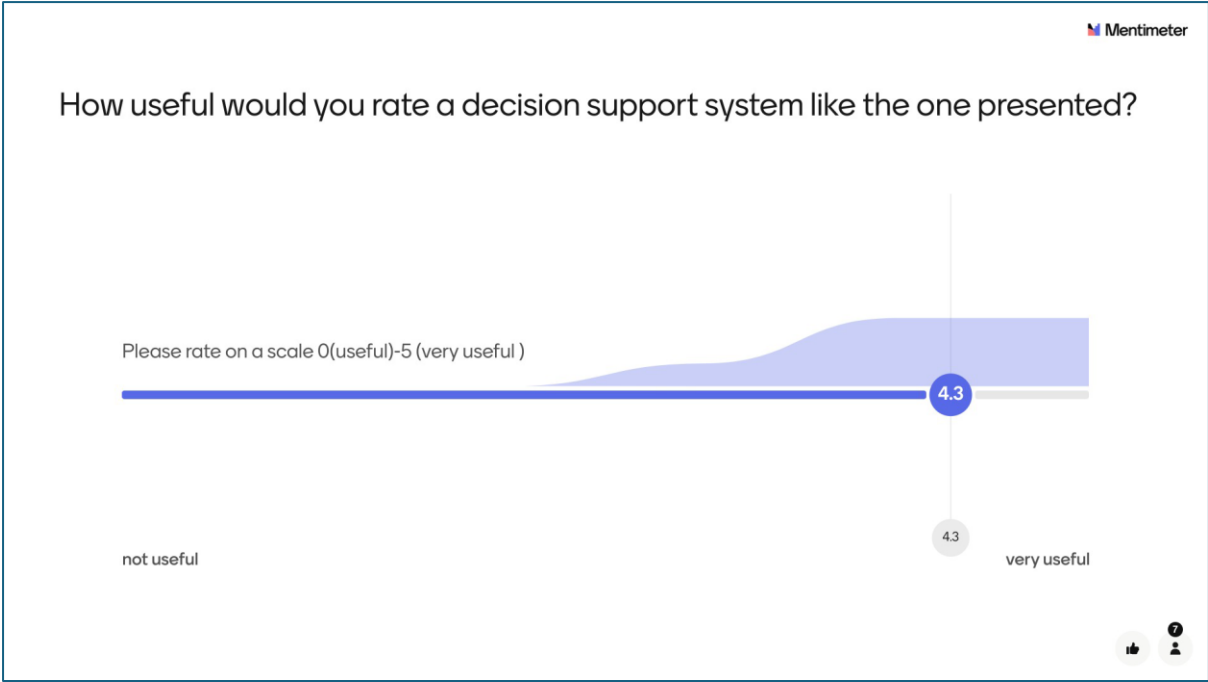


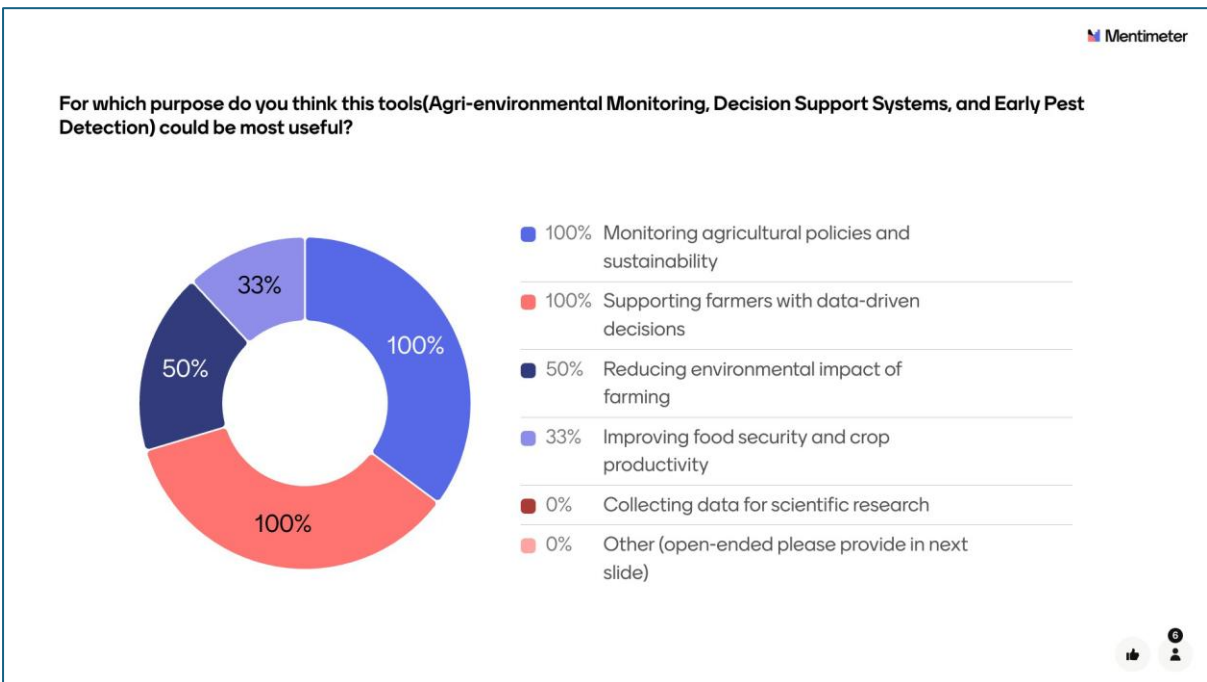
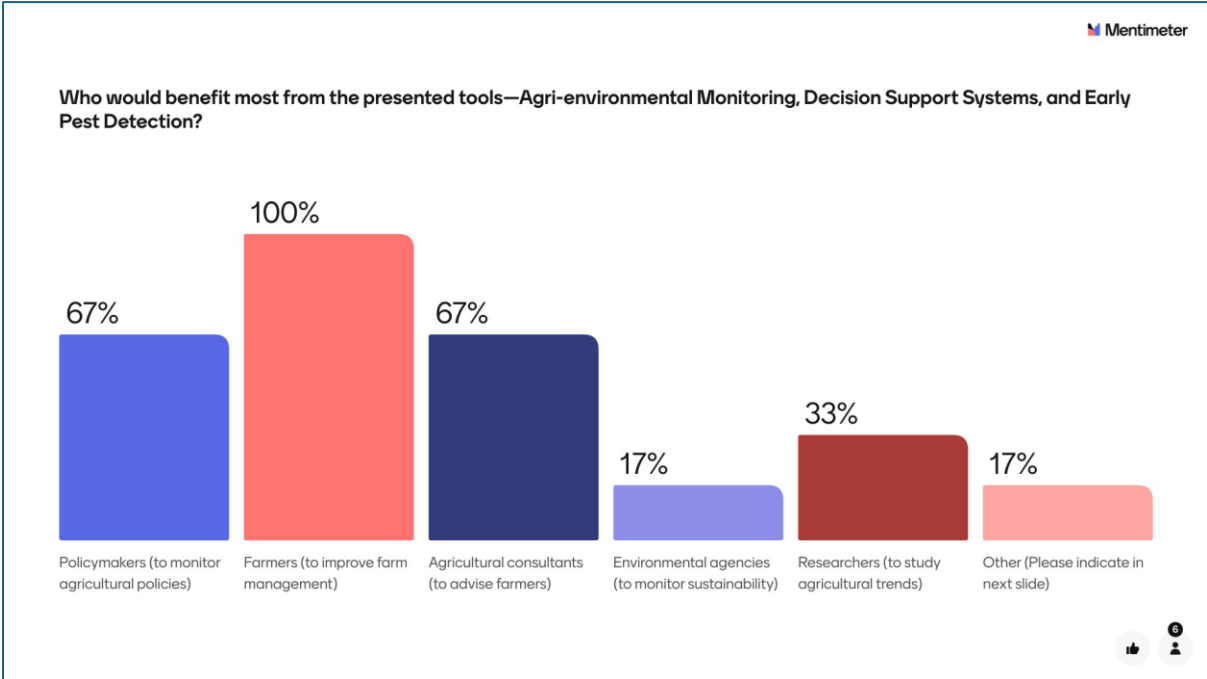
- 13% • Offline functionality for areas with weak internet access
- 56% • Customization based on regional climate and soil conditions
- 75% • Easier integration with existing irrigation and farm management tools/ systems
- 69% • More localized datasets and satellite imagery
- 44% • Improved data-sharing policies with clear privacy protections

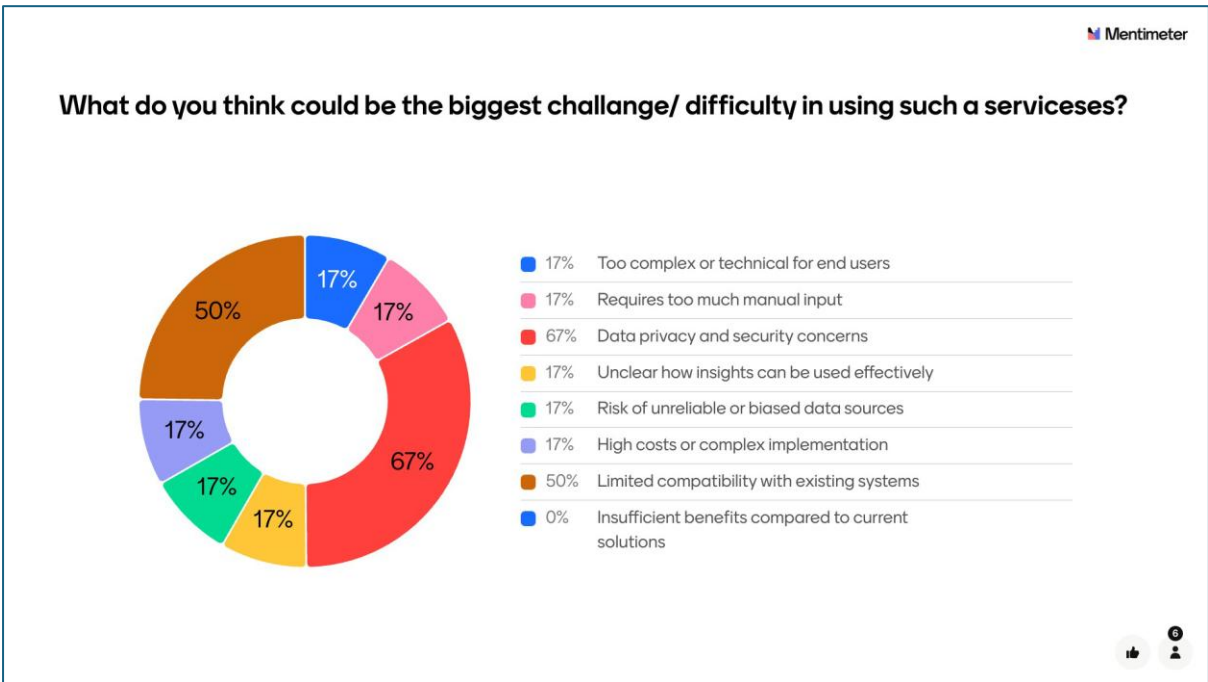
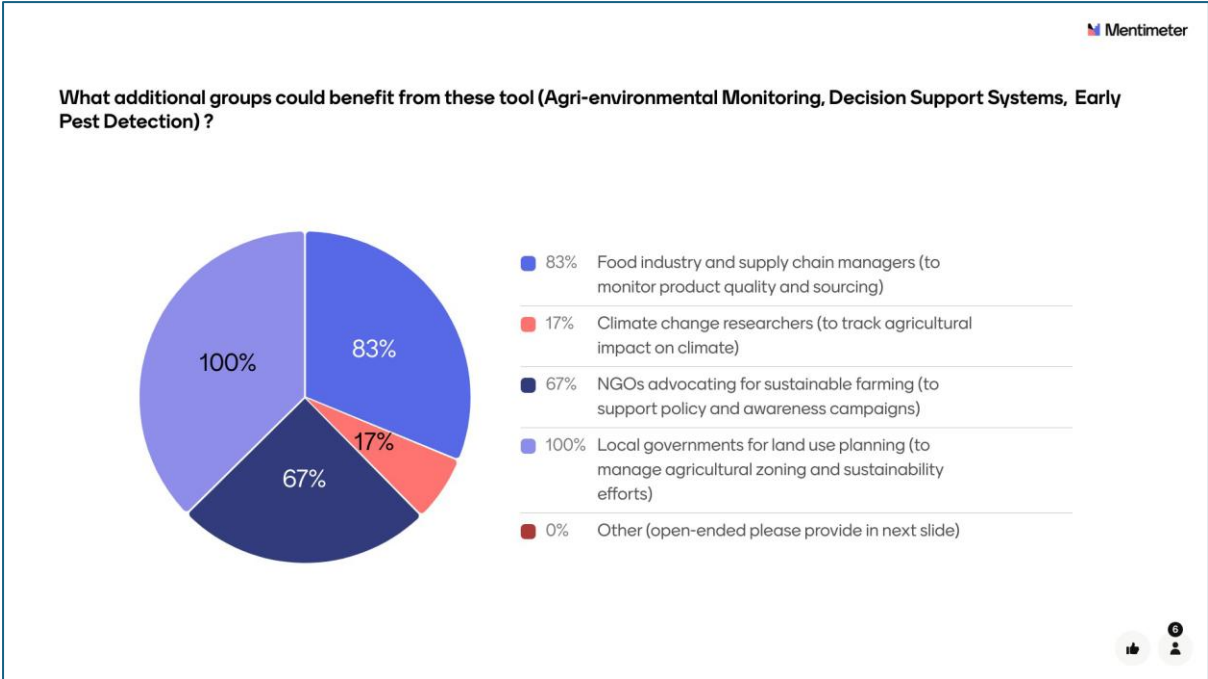


5.4.2 RIL 2 Crop Management Mentimeter



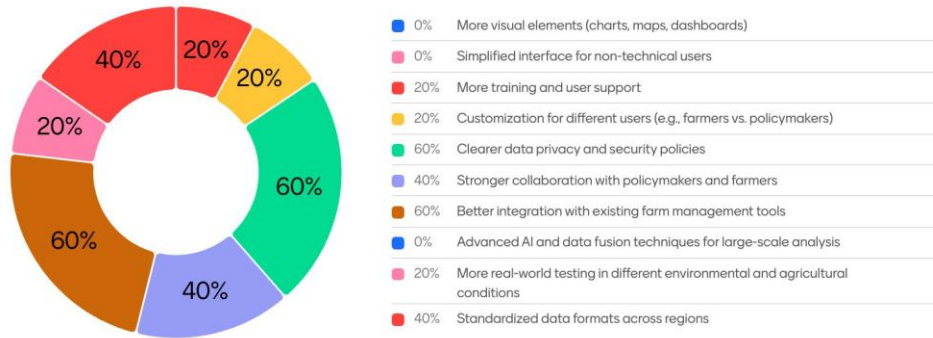






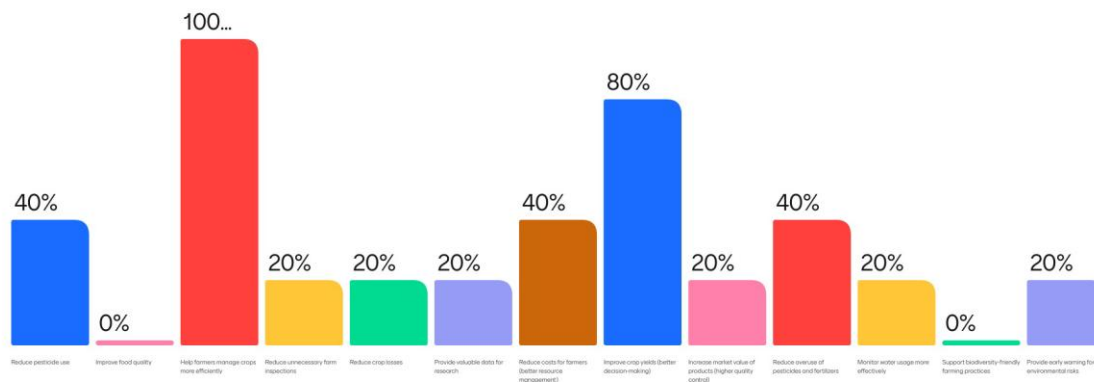
Mentimeter

What improvements would make this tool more practical and widely adopted?

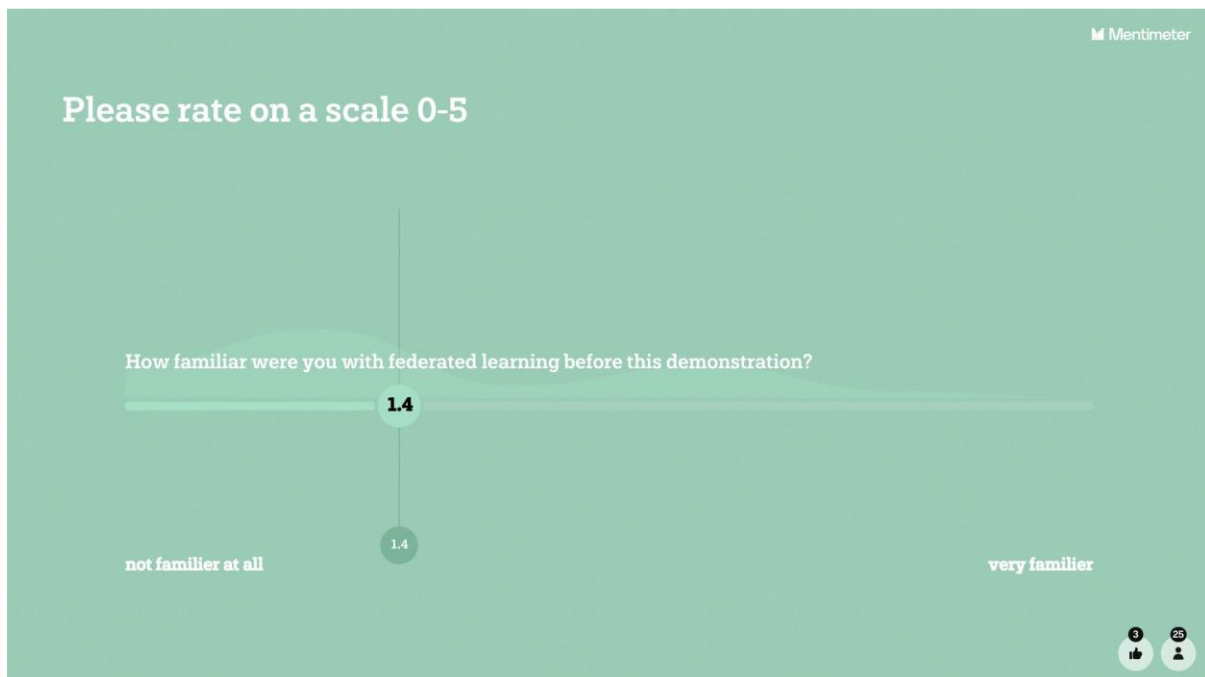
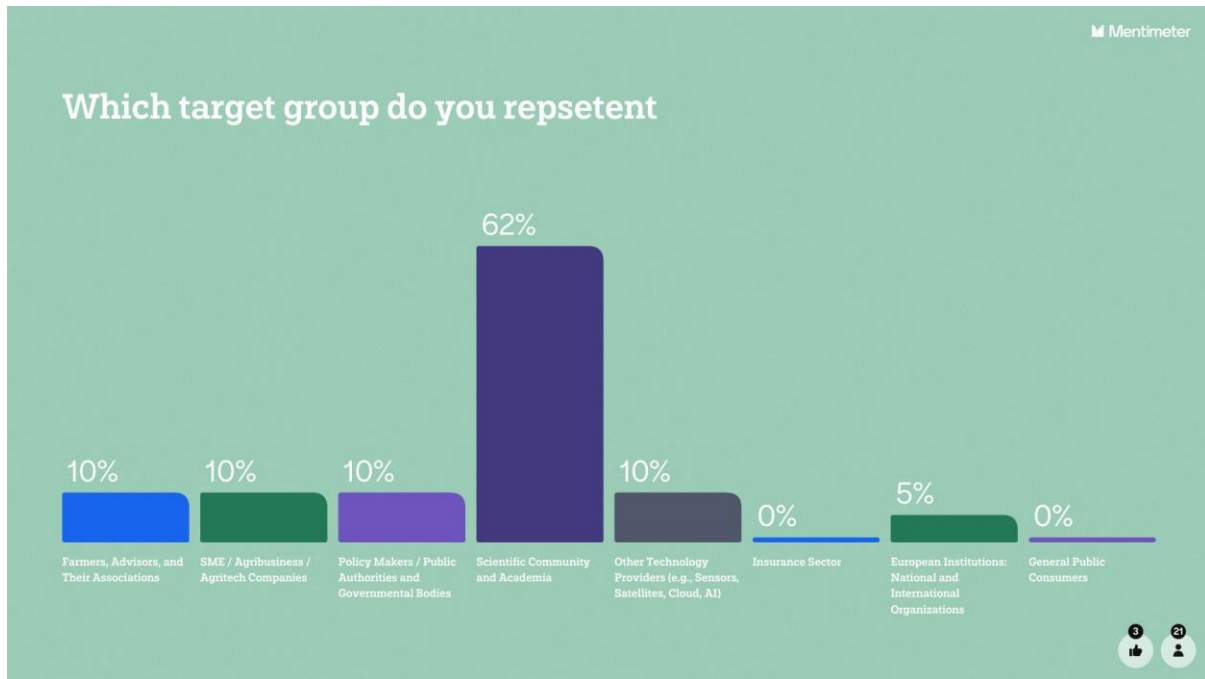


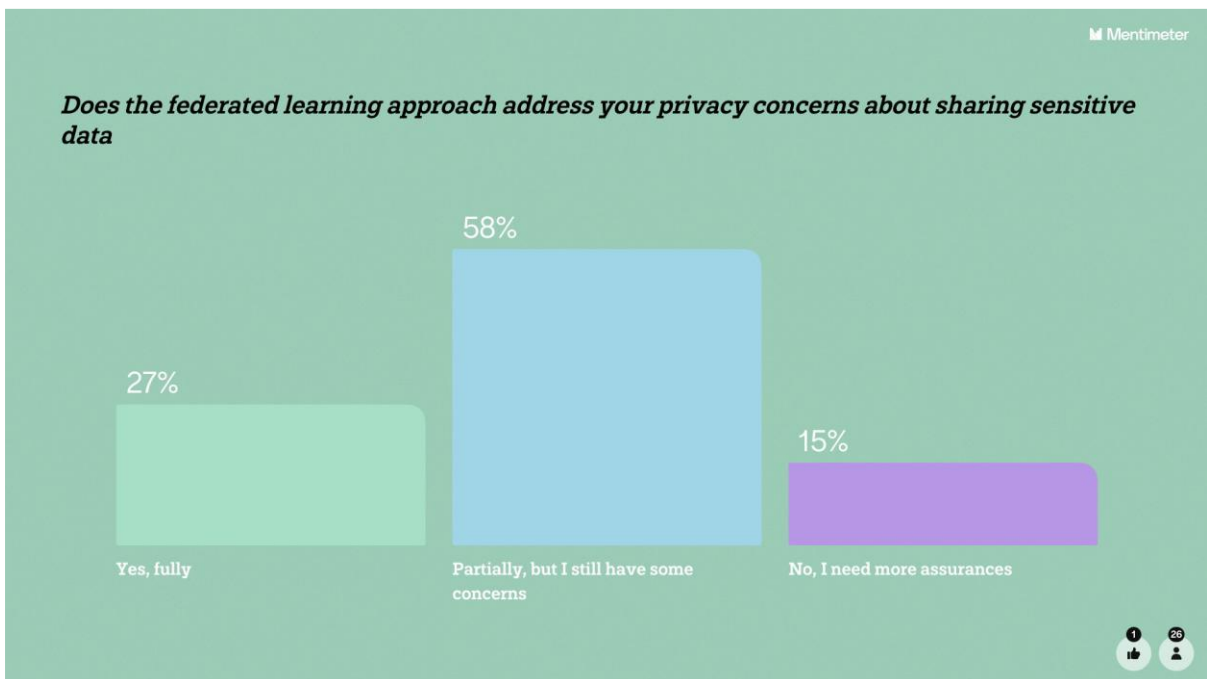
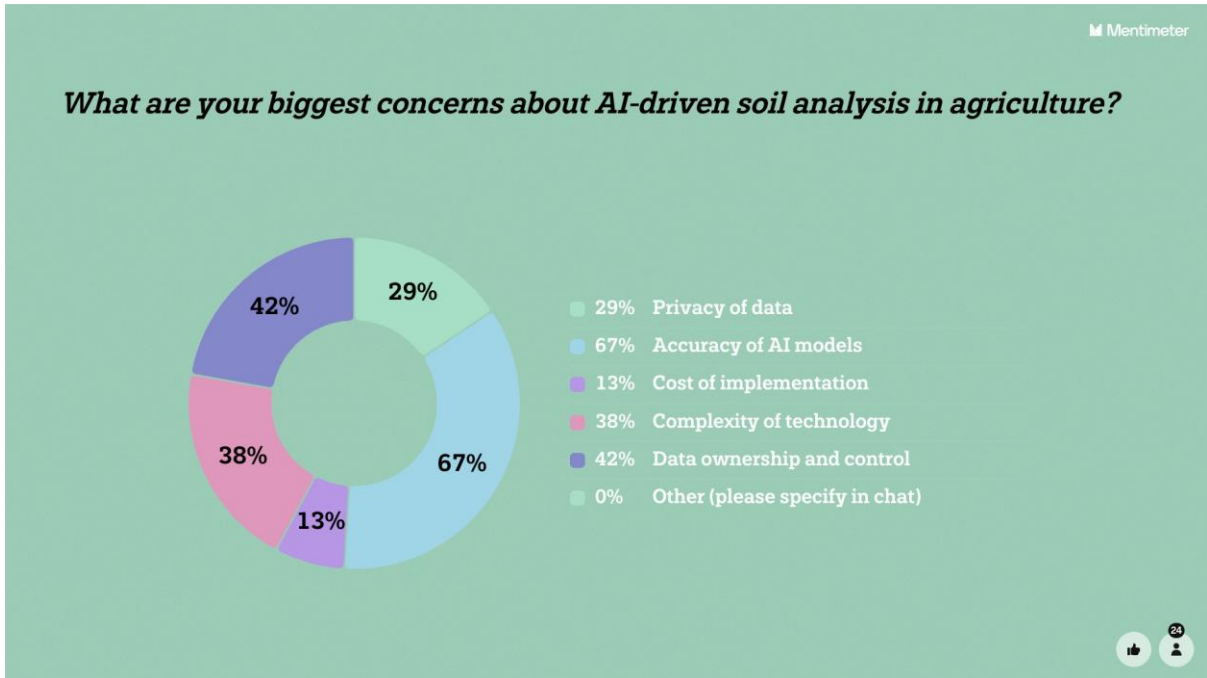
Mentimeter

What potential benefits could these services provide for your work or the user group you represent?



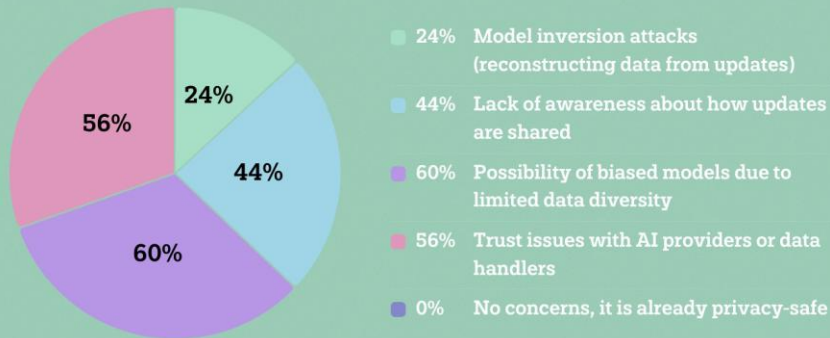
5.4.3 RIL4 Soil RIL Mentimeter





Mentimeter

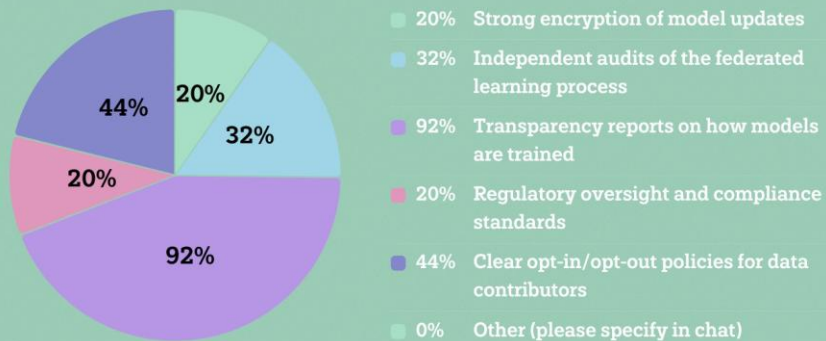
What potential privacy risks, if any, do you see in Federated Learning?



2 25

Mentimeter

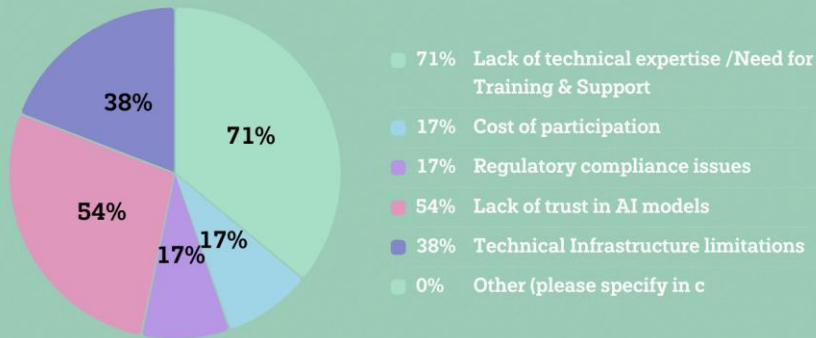
What measures would increase your confidence in the privacy and security of federated learning?max 3 choice



2 25

Mentimeter

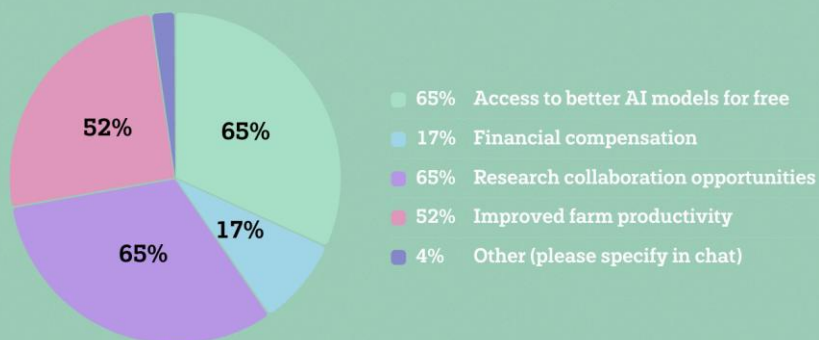
What challenges do you foresee in implementing federated learning for soil analysis?



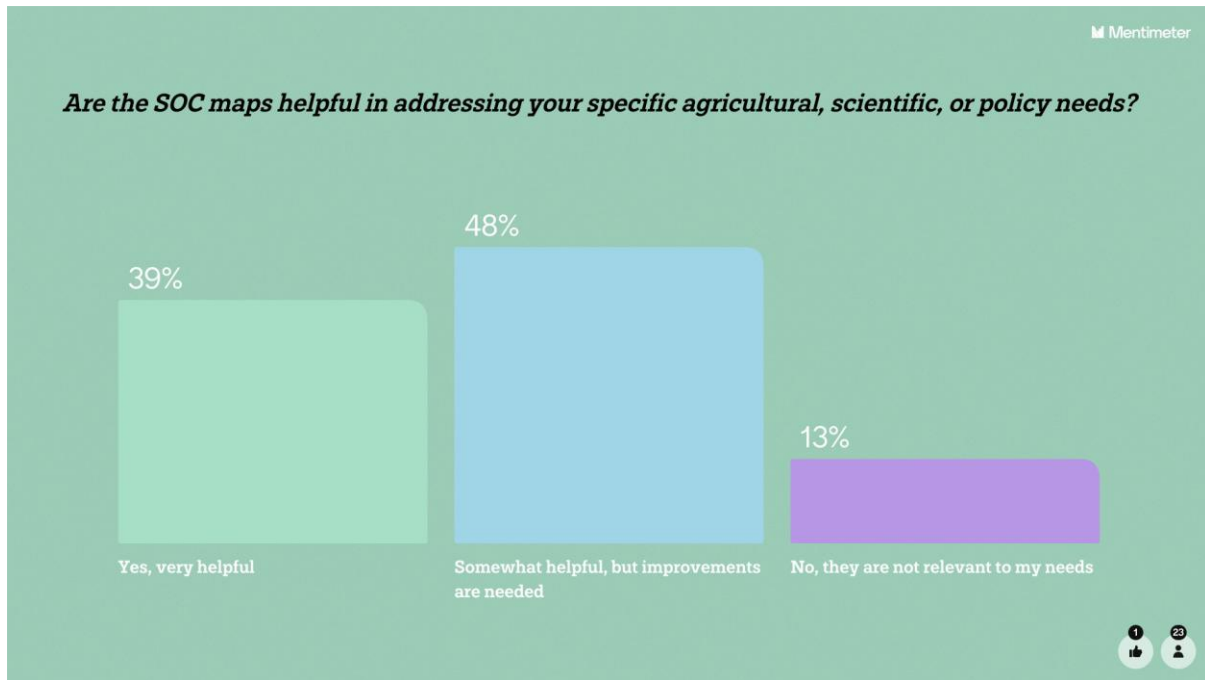
1 23

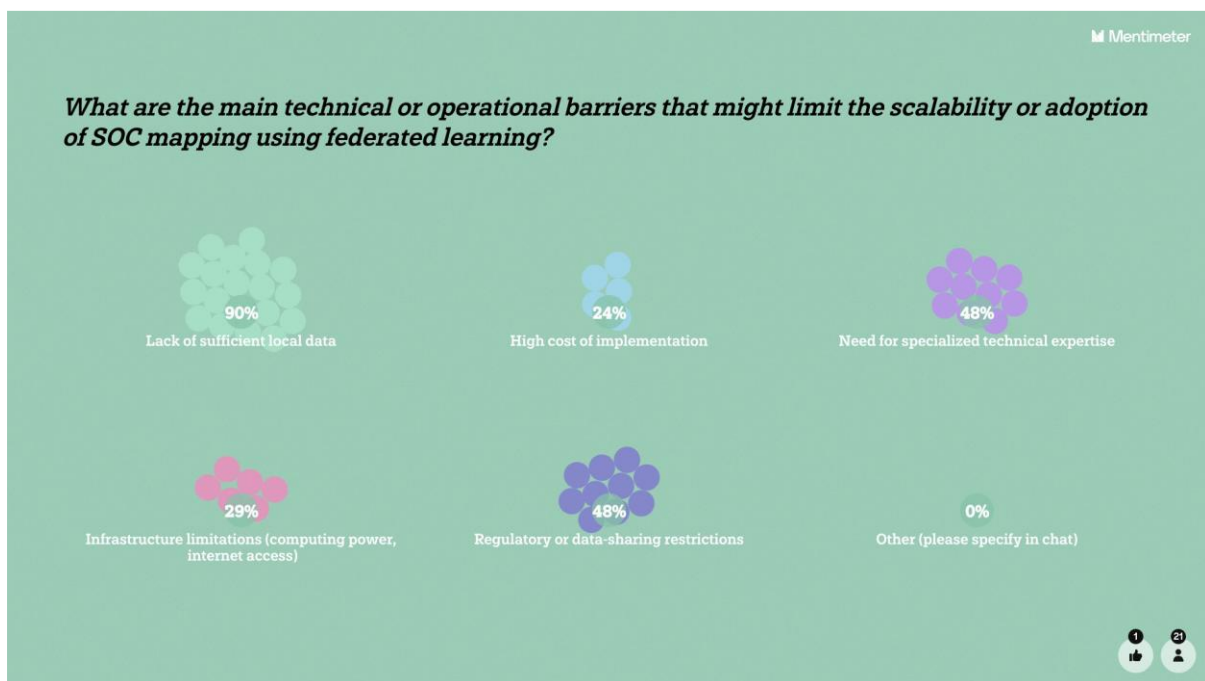
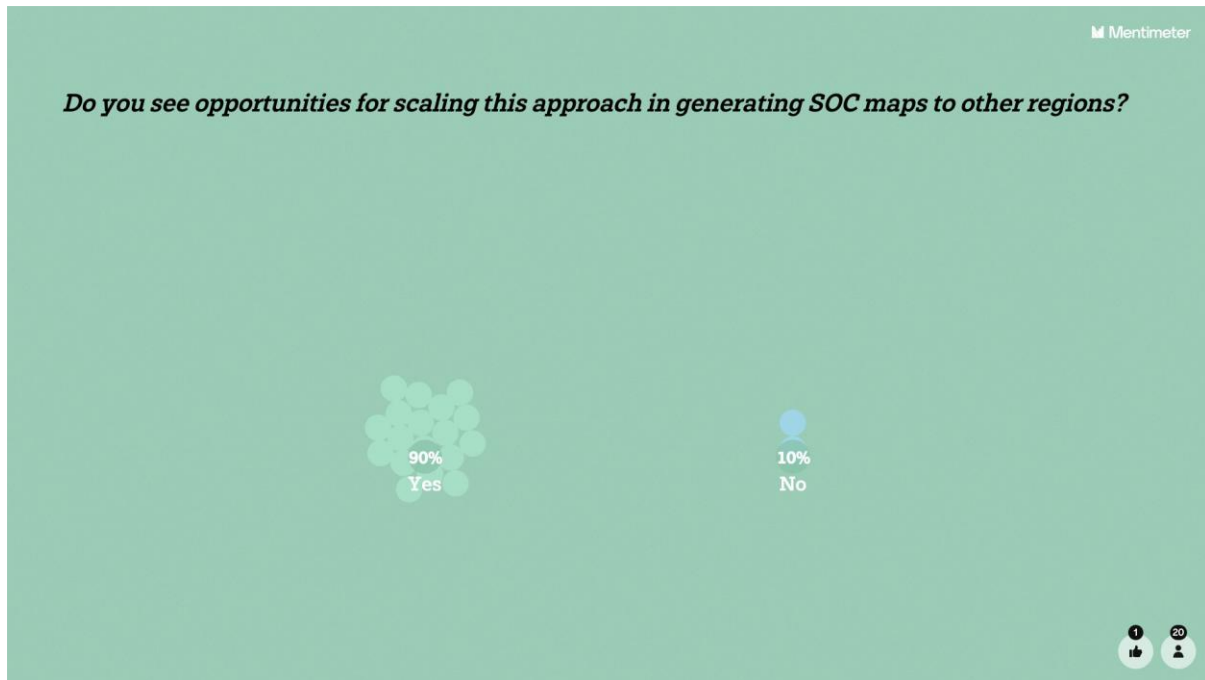
Mentimeter

What benefits would motivate you to contribute data?



1 23





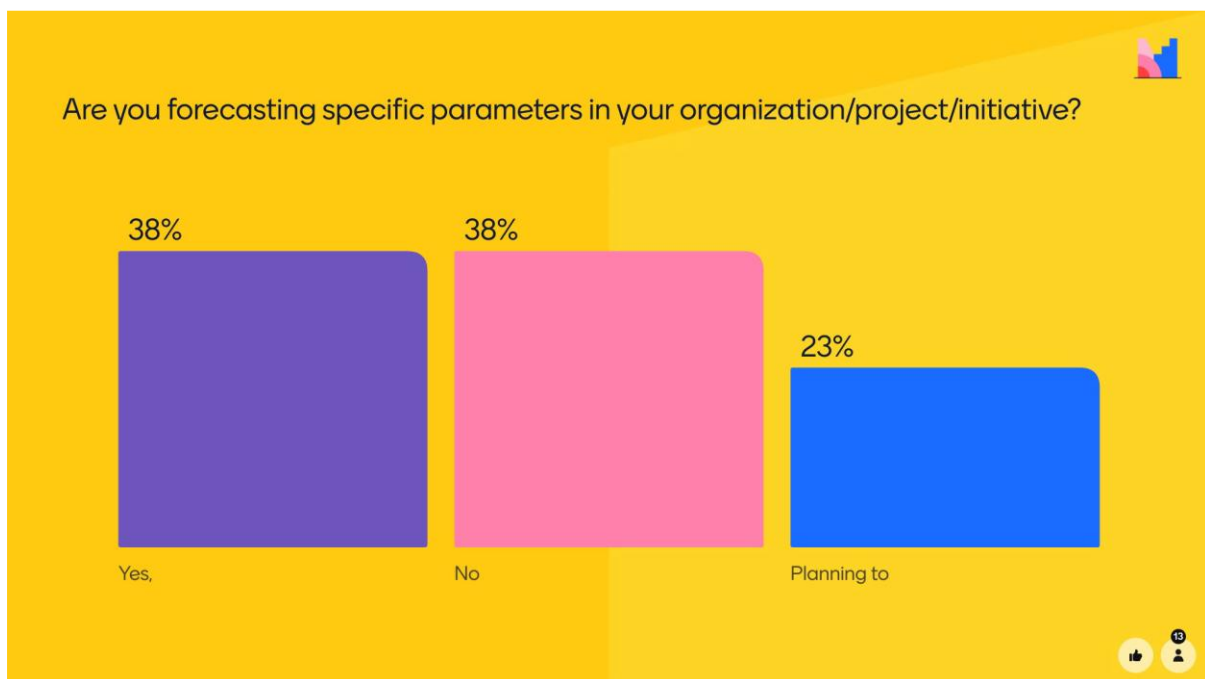
Mentimeter

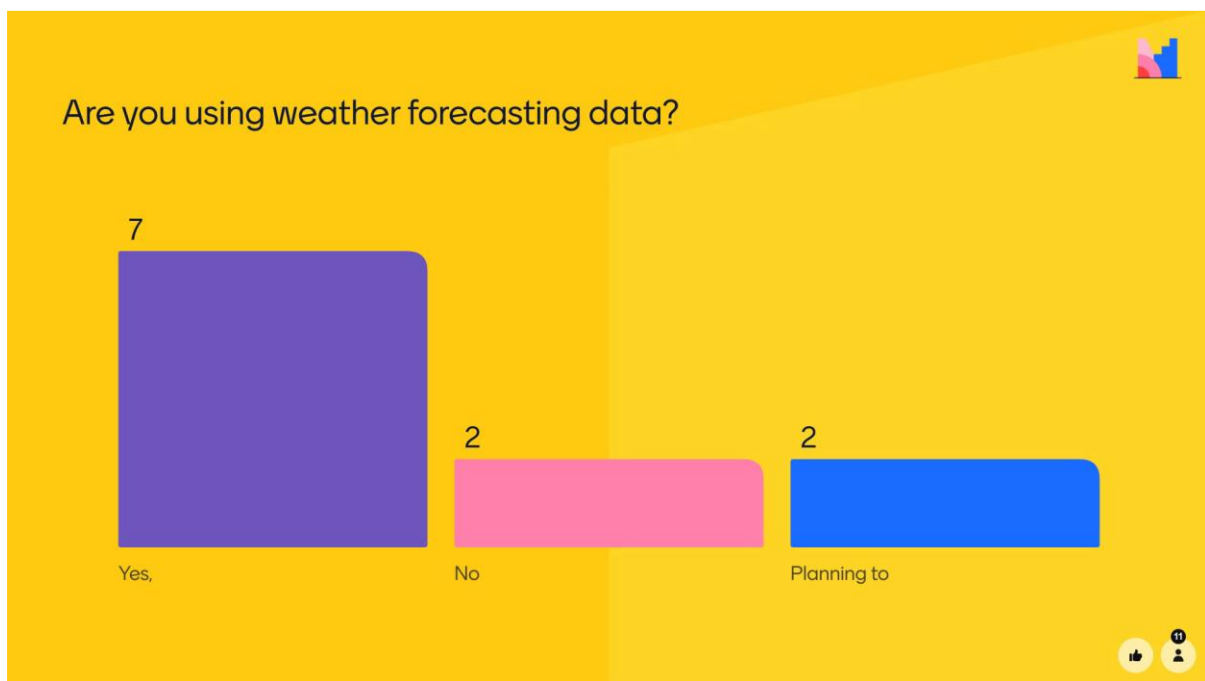
Beyond SOC mapping, what other agricultural challenges do you think federated learning could address effectively?

21 responses

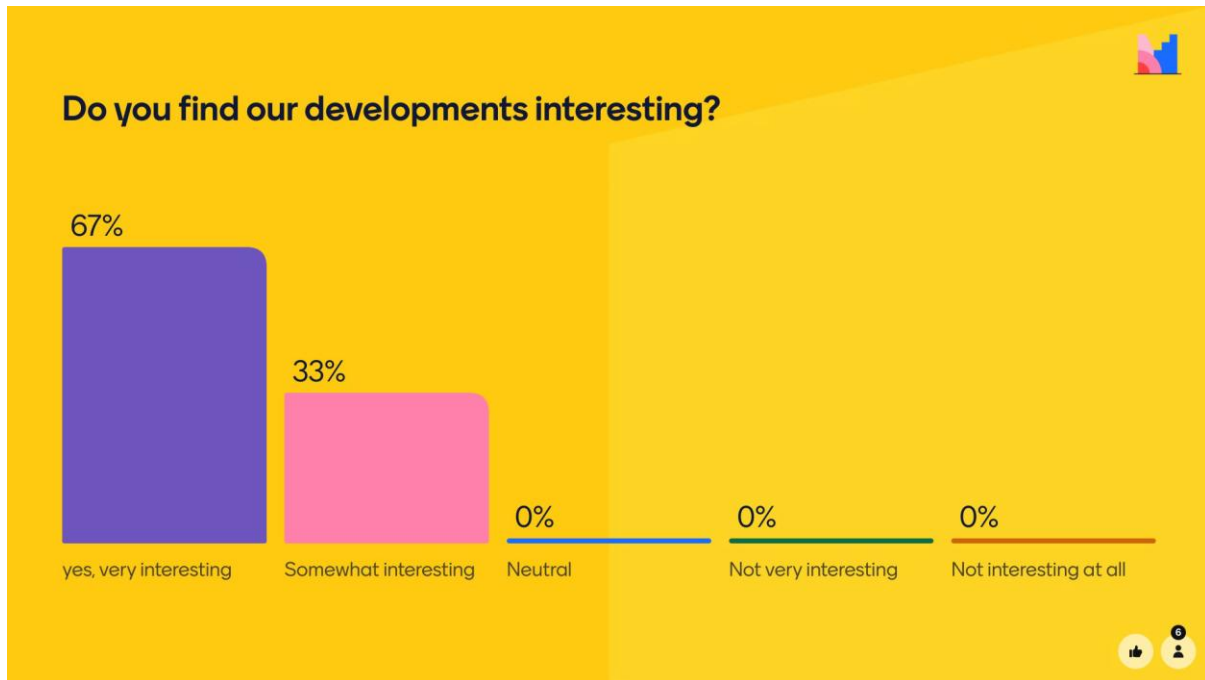


5.4.4 RIL6 Dairy RIL Mentimeter









Why do you find our developments interesting (or not), and in which way would they benefit your work?

Its a future of Agriculture, and animal welther

It opens opportunities for collaboration with industry stakeholders, or policymakers, researchers

not benefitting directly my work but generally great to see how we can aggregate data along the production chain of agricultural products - good for the sector!

they will be beneficial for dairy production management