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# AgriDataValue

## Smart Farm and Agri-environmental Big Data Value

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# Practice Abstract Volume 2

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# Table of Contents

**Definitions, Acronyms and Abbreviations** ........ **5**

**Executive Summary** ........ **6**

**1 Introduction** ........ **7**

1.1 PA5: AI-Based Pest Detection for Earlier and Smarter Crop Protection ........ 8

1.2 PA6: Digital Circular Farming: How Data-Driven Practices Help Farmers Meet CAP Environmental Standards ........ 10

1.3 PA7: Turning Farm Data into Value – Data Ownership, Interoperability and New Business Models for Farmers ........ 12

1.4 PA8: From Field Sensors to Digital Twins – How Integrated Hybrid Sensing Supports Real-Time Farm Decisions ........ 13

# Definitions, Acronyms and Abbreviations

| | |
|---|---|
| EIP-AGRI | European Innovation Partnerships for Agricultural Productivity and Sustainability |
| AI | Artificial Intelligence |
| CAP | Common Agricultural Policy |
| ML | Machine Learning |
| ViTs | Visual Transformers |
| PA | Practice Abstract |
| IoT | Internet of Things |

# Executive Summary

This second volume of AgriDataValue Practice Abstracts continues the project’s mission of translating research outcomes into actionable insights for practitioners, farmers, advisors, and agri-environment stakeholders. Together with Volume 1 delivered at M17 and the forthcoming Volume 3 scheduled for M60, this document forms part of the project’s contribution to the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) and supports the wider dissemination of knowledge generated within the AgriDataValue ecosystem.

Volume 2 captures recent progress in data-driven and AI-enabled agricultural solutions, focusing on practical innovations emerging from the project’s pilots and technical developments. The four Practice Abstracts included in this edition reflect the project's core advancements in machine learning, hybrid sensing, digital circularity, and farmer-centric data governance. They provide clear, concise explanations of the technologies tested, their benefits, and guidance for farm-level application.

The topics covered in this volume are:

**PA5: AI-Based Pest Detection for Earlier and Smarter Crop Protection** – A machine-learning approach enabling faster pest identification, supporting integrated pest management and reducing unnecessary chemical use.

**PA6: Digital Circular Farming: How Data-Driven Practices Help Farmers Meet CAP Environmental Standards** – Practical examples of how digital tools support nutrient management, soil protection, and climate-smart agriculture within the CAP conditionality system.

**PA7: Turning Farm Data into Value – Data Ownership, Interoperability and New Business Models for Farmers** – An overview of how transparent governance, standardised formats and interoperable systems empower farmers to control and benefit from their data.

**PA8: From Field Sensors to Digital Twins – How Integrated Hybrid Sensing Supports Real-Time Farm Decisions** – Insights from pilots demonstrating how linking IoT devices, drone and satellite data enables digital twins that improve operational precision and resilience.

Abstracts follow the EIP-AGRI style, ensuring compatibility with EU knowledge-sharing platforms and supporting broad dissemination to agricultural communities across Europe.

# 1 Introduction

This deliverable presents the second set of Practice Abstracts (PAs) prepared within WP6 – Impact Creation & Outreach of the AgriDataValue project. It builds on the first volume (D6.11) and incorporates the most recent technological developments, field experiences, and pilot results generated across several countries and farming systems. Together, the PAs included here aim to bridge the gap between advanced research and everyday agricultural practice.

The overarching purpose of the Practice Abstracts is to support the flow of knowledge towards farmers, advisors, and rural practitioners by delivering concise, practice-oriented insights structured in line with the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) guidelines. These short, accessible formats contribute directly to the EU's objective of enhancing innovation uptake in agriculture, strengthening coherence between research activities and the Common Agricultural Policy (CAP), and ensuring that project-generated innovations reach end users in a practical and understandable way.

In this second volume, the focus shifts towards four complementary themes that reflect AgriDataValue's most recent technological achievements and use-case advancements:

- AI-enabled pest detection and phenology prediction, addressing the growing need for early-warning tools adaptable to climate variability (PA5);
- Digital circular and regenerative farming solutions, helping farmers meet CAP conditionality and environmental performance objectives through data-driven management (PA6);
- Farmer-centred data governance and business models, illustrating how transparent rules and interoperability increase trust and help farmers benefit economically from their data (PA7);
- Hybrid sensing and digital twins, demonstrating how the integration of IoT, remote sensing, and machine data supports real-time operational decisions (PA8).

These abstracts collectively demonstrate how advanced data processing, artificial intelligence, and integrated sensing can be translated into concrete actions on farms, supporting the transition toward more efficient, resilient and sustainable agricultural systems.

Prepared in a traditional narrative style, yet following the EIP-AGRI format, Volume 2 provides a coherent and practice-based contribution to AgriDataValue's dissemination activities. It also establishes a foundation for the final set of PAs (Volume 3), which will synthesise the project's long-term impacts and lessons learned.

## 1.1 PA5: AI-Based Pest Detection for Earlier & Smarter Crop Protection

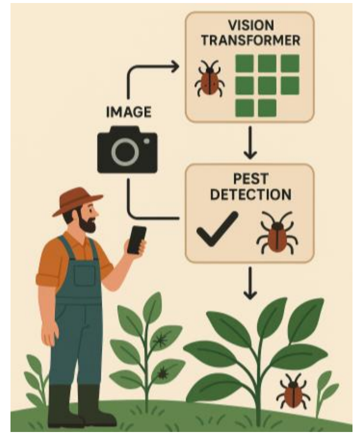

*Figure 1: AI Pest Detection*

Pest pressure remains one of the most significant causes of yield losses across European agriculture, and these risks are becoming more unpredictable due to climate variability and changing crop regimes. Conventional scouting methods often require substantial labour, depend heavily on the farmer's experience, and may miss early, subtle symptoms—especially when several pests have similar visual characteristics. As a result, many farms rely on broad preventive spraying, which increases production costs and raises concerns regarding resistance management and environmental impact. For growers trying to safeguard margins and maintain soil and crop health, these challenges have real economic and operational implications. Against this background, digital tools capable of recognising pest presence more quickly and accurately offer a promising direction for both more effective and sustainable plant protection.

Within the AgriDataValue project, researchers at Queen Mary University of London developed an advanced pest-recognition model based on Visual Transformers (ViTs), a deep-learning architecture well suited to fine-grained image classification. The team assembled a large and diverse dataset containing more than 80,000 images representing 80 economically relevant pest species. These include threats common to major European crops such as apples, tomatoes, wheat and maize, but also species found in global production systems, reflecting the broader need for adaptable detection tools. The resulting model can distinguish visually similar pests at early stages and has been designed so that its outputs can be integrated into the wider AgriDataValue data ecosystem alongside weather information, remote-sensing indicators and on-farm IoT measurements.

For farmers, the practical value of this innovation lies in its simplicity. The technology does not require specialised sensors as clear images captured with a smartphone, greenhouse camera or drone can be analysed to indicate whether a pest is likely present and in which part of the field. This can act as an early-warning system, prompting more targeted scouting rather than relying on routine, field-wide inspections. The approach therefore saves time and helps farmers focus their efforts where interventions bring the biggest return. In practice, this means less time spent walking fields without clear targets and more time directed to areas where timely action can prevent losses. When used as part of an integrated pest-management strategy, the tool supports decisions on whether to monitor a suspected infestation more closely, treat a confined hotspot or prepare for a more serious outbreak affecting a larger share of the crop.

Farm experiences gathered during early trials show that AI-supported detection can help reduce unnecessary spraying and better align plant-protection practices with sustainability requirements under the current CAP framework. Even small improvements in timing—such as identifying a pest two or three days earlier—can prevent more extensive damage and, in some cases, reduce the need for chemical treatment altogether. The model's broad crop coverage is particularly beneficial for mixed and rotating farms, which often struggle to combine multiple pest-monitoring systems. A single tool capable of recognising many species offers a more coherent and scalable approach to farm-level surveillance. This also reduces the hassle of switching between different apps or systems during the season.

To make the best use of the tool, farmers are encouraged to begin with a small pilot area. This allows them to build confidence in how the system behaves under their specific conditions, crops and lighting environments.

Good image quality strengthens accuracy: photographs taken in daylight, with clear focus on the affected parts of the plant, provide the most reliable results. Many farmers integrate this step naturally into existing routines such as weekly crop walks or drone flights already used for growth monitoring. Farmers should treat alerts as guidance rather than as standalone diagnosis. The most effective implementations combine AI-based signals with the farmer's own field knowledge, leading to decisions that are both data-informed and locally validated.

Seasonal evaluation is recommended to understand the impact on costs and yields. Farmers may compare the number of scouting hours saved, changes in pesticide use, the frequency of severe outbreaks and the financial implications for their farm business. This helps clarify how the tool contributes to improved margins or reduced production risks. In many cases, benefits become more visible over time as farmers refine their routines and as the underlying model improves with broader datasets and updated classifications.

Overall, AI-based pest detection represents a practical and accessible step towards more precise and environmentally responsible crop protection. By integrating early-warning signals into everyday management practices, farms can reduce chemical inputs, protect yields, improve labour efficiency and contribute to wider sustainability goals. As the AgriDataValue project continues to expand its platform, farmers can expect increasing opportunities to combine pest-detection outputs with other digital services, creating a more holistic foundation for data-driven decision making on the farm.

## 1.2 PA6: Digital Circular Farming: How Data-Driven Practices Help EU Farmers Meet CAP Environmental Standards

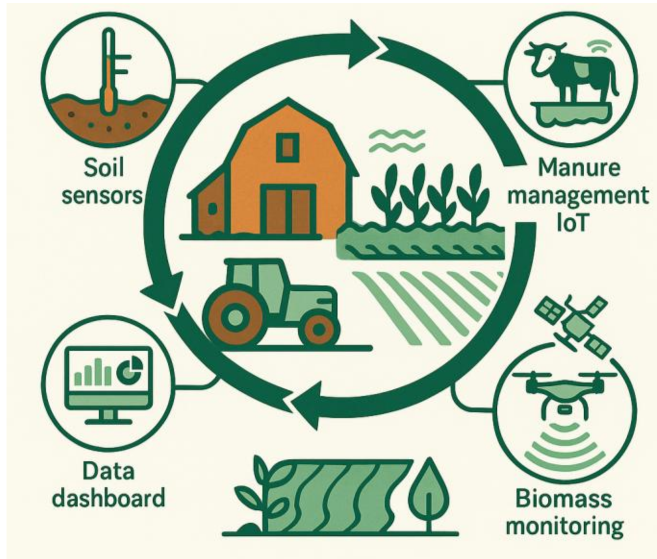


*Figure 2: Digital Circular Farming complying with CAP requirements*

Building on the environmental and climate objectives described in PA2, this Practice Abstract demonstrates how digital technologies within AgriDataValue enable practical circular-economy solutions that help farmers comply with CAP conditionality while improving efficiency and profitability. For farming businesses, this means turning policy requirements into practical tools that support both daily operations and long-term resilience.Across European agriculture, the pressure to reduce environmental impacts while maintaining economic viability has never been stronger. Farmers today must respond not only to rising fertiliser and energy prices but also to the growing expectations embedded in the CAP 2023–27 framework, particularly the conditionality system and eco-schemes encouraging reduced nutrient losses, better soil management and lower emissions. This creates a dual challenge for farmers who must stay profitable while demonstrating environmental care. While these ambitions are clear, many farms still struggle to operationalise circular practices in a practical, day-to-day manner. Digital tools emerging from AgriDataValue offer new possibilities: farmers can monitor resource flows, detect inefficiencies sooner and adapt management decisions in ways that protect the environment while supporting the economic sustainability of their holdings.

Circular farming aims to keep nutrients, water and biomass within the farm system for as long as possible. Typical examples include using crop residues to improve soil organic matter, applying manure or digestate precisely to crop needs, reducing fertiliser over-application, and adjusting irrigation schedules to reduce runoff and soil degradation. Although such measures have been promoted for years, their adoption is often limited by the difficulty of monitoring soil conditions accurately, tracking nutrient balances in real time, or understanding when and where emissions or losses occur. For farmers working under time pressure, these monitoring challenges often make circular practices feel complex or risky to implement. Paper-based documentation and manual observations often fail to capture the spatial and temporal complexity that circular practices require.

Digitalisation substantially reduces these barriers. Within AgriDataValue, several technologies—soil moisture and nutrient sensors, livestock and manure-management IoT systems, drone and satellite biomass mapping, and farm-level data dashboards—work together to provide a clearer picture of how resources circulate within the farm. For example, soil sensors positioned along a field allow farmers to monitor moisture variations across different zones, supporting more efficient irrigation scheduling. Similarly, digital tools estimate the nutrient content of manure or digestate and help visualise how these resources are distributed across fields over the season. This allows farmers to avoid over- or under-application, saving costs while protecting yields. By integrating these measurements with crop growth data and local weather conditions, farmers can choose more precise application timings and adapt to changing conditions with much greater confidence.

A central advantage emerges from linking these digital observations with CAP standards. Many of the key GAEC rules—such as minimum soil cover, erosion prevention, buffer strips, reduced fertiliser losses or prohibition of manure spreading under certain conditions—become easier to manage when farmers have data-based insights. Rather than viewing conditionality as a compliance burden, many farmers in pilot studies began to treat digital tools as supportive instruments that allowed them to anticipate potential breaches before they occurred. For instance, weather-linked DSS alerts can signal when soil moisture is too high for manure application, or satellite-derived vegetation maps can help farmers verify that required buffer zones along water bodies are maintained. This reduces risk during inspections and increases farmers' confidence in meeting environmental commitments.

The economic benefits are also tangible. Pilot experiences show that even modest reductions in fertiliser input—achieved through more accurate nutrient matching and better timing—can deliver meaningful cost savings, especially for mixed livestock–arable farms. Improved soil organic matter through better residue use contributes to long-term yield stability and water retention. In areas facing drought pressure, combining efficient irrigation with biomass mapping helps prevent overwatering and reduces energy costs for pumping. These improvements can accumulate into more stable margins and better crop performance, especially in challenging seasons. As farmers refine these circular strategies year after year, the cumulative benefits become stronger and more visible in both financial performance and soil health indicators.

As with any new technology, successful adoption requires a step-by-step approach. Farmers are encouraged to begin with a single resource flow (such as irrigation or manure distribution) and to integrate digital tools gradually, learning how the system responds under their specific crop rotations, soil types and climate conditions. Clear record-keeping and seasonal comparison help quantify the benefits: reductions in input use, stability in yields, decreases in soil compaction, or lower levels of runoff and nutrient loss. Over time, these insights can support participation in eco-schemes and other CAP interventions rewarding climate- and environment-friendly practices.

Digital circular farming therefore offers a realistic and accessible path towards meeting both environmental and economic goals. By combining on-farm data, remote sensing and user-friendly advisory tools, AgriDataValue helps transform circularity from an abstract ambition into a set of concrete, data-informed actions. Farms that adopt these practices not only reduce their environmental footprint and comply more easily with CAP requirements but also strengthen their long-term resilience in the face of climate variability and increasing input costs.

## 1.3 PA7: Turning Farm Data into Value – Data Ownership, Interoperability and New Business Models for Farmers

Modern farms generate increasing volumes of information from machinery, sensors, drones, satellite imagery and routine field operations, but much of this data remains unused because it is stored in incompatible formats, scattered across different platforms or shared without clear rules about ownership. This often leaves farmers unsure whether the effort of collecting data pays off in day-to-day management. Farmers often feel they are producing valuable information without knowing how it is used or how it might benefit their business. AgriDataValue addresses this challenge by placing farmers at the centre of a transparent and interoperable data ecosystem. The project's approach helps identify what data is already available on the farm, how it can be combined with external datasets, and how reliable governance rules can ensure that farmers maintain control over its use.

Experience from project pilots shows that well-structured farm data generates clear, practical advantages. Advisory tools become more accurate when soil measurements, crop information, machinery logs and weather data can be used together. Interoperability between platforms reduces duplication of effort and allows seamless transfer of records between machines, farm management systems and advisory services. This saves time on routine tasks and reduces errors that occur when information must be entered multiple times. Data-sharing agreements tested in the project demonstrate that farmers can retain full control of their data while still benefiting from collaborative analytics or access to digital marketplaces. In many cases, transparent rules build trust and allow farmers to negotiate better contracts with service providers, because they know exactly who uses their data and for what purpose.


*Figure 3. Farmer's Data-to Value Checklist*

A step-by-step approach works best. Farmers can begin by identifying what information they already collect, such as soil maps, irrigation records or pest observations, and ensuring that these datasets can be exported in open or standardised formats. Asking service providers about data access, storage and re-use helps clarify ownership and avoid misunderstandings. Starting with a single area—for example, irrigation logs or field scouting data—makes it easier to integrate the information into decision-support tools and evaluate the benefits. Over time, farms can monitor how data-driven insights reduce input costs, save time, support compliance with CAP requirements or open opportunities for new services. This gradual approach ensures that each improvement delivers a concrete return before moving to the next step.

In the longer term, participation in secure and interoperable data spaces strengthens farmers' resilience. Improved decision quality reduced administrative burden and better access to digital tools contribute directly to farm performance. As agricultural data becomes increasingly valuable, the ability to manage, share and negotiate its use becomes a key competence—one that AgriDataValue helps farmers build through simple, practical steps grounded in everyday farm realities.

## 1.4 PA8: From Field Sensors to Digital Twins – How Integrated Hybrid Sensing Supports Real-Time Farm Decisions

Hybrid sensing—linking IoT devices, drones, satellites and farm machinery data—has emerged as one of AgriDataValue’s strongest innovations. Building on early project pilots, several use cases demonstrate how combining these data streams into a single digital representation of the field or livestock environment enables much faster, more precise agricultural decision making. These tools help farmers adapt to weather extremes, reduce input use and anticipate risks before they escalate. For many farmers, this means gaining earlier insight into problems that would otherwise show up only when yield losses are already unavoidable.

Digital twins created within AgriDataValue serve as “live maps” of the farm, continuously updated with soil moisture readings, canopy measurements, weather forecasts, pest alerts and machinery logs. Unlike traditional standalone monitoring tools, digital twins integrate data sources automatically, showing the farmer how different parameters interact. For instance, soil moisture can be analysed together with leaf wetness and canopy density and linked to weather forecasts to highlight areas at risk of water stress or fungal infection. This unified approach improves the accuracy of advisory tools and lowers the time needed to interpret raw data.


*Figure 4. Digital twin in Smart Farming*

Sensor deployments in project pilots show that hybrid sensing is especially helpful for managing variability inside fields. In vineyards, real-time micro-climate stations combined with high-resolution drone imagery allowed farmers to adjust irrigation and spraying schedules in ways that reduced water use and improved disease-prevention timing. In arable systems, IoT soil probes positioned at multiple depths helped detect localised drought stress earlier than visual inspection alone. The real-time view also supports more targeted interventions—farmers can treat specific zones instead of the entire field, thereby reducing costs and environmental impact.

Livestock pilots demonstrate similar benefits. Temperature–humidity measurements inside barns, combined with smart feeding and water-consumption logs, help farmers respond to heat stress events and optimise animal comfort. Early-warning indicators generated by the digital twin show changes in behaviour or barn micro-climate conditions, allowing adjustments before they affect performance or welfare. These insights can also support compliance with CAP and animal-welfare standards.

A key advantage of this integrated approach is its simplicity for the end user. Data automatically flows into a unified dashboard via the AgriDataValue platform, requiring no special technical expertise. Farmers benefit from clear visual summaries and tailored recommendations rather than needing to interpret multiple sensor interfaces. The system also supports gradual adoption: farmers can begin with a small set of IoT devices or drone images and integrate additional data layers over time. Each season increases the precision of the digital twin and reveals new opportunities for optimisation. This keeps the learning curve manageable while ensuring that every new data layer delivers added value.

For best results, farmers are encouraged to start with one or two indicators that are most relevant to their production challenges—such as soil moisture, canopy temperature or barn climate—and to assess how the insights change decision patterns. Seasonal comparisons are valuable: farmers can evaluate reductions in water use, improvements in crop uniformity, or decreases in pest or heat-stress events. Over time, hybrid sensing helps build more resilient production systems by supporting data-based interventions aligned with sustainability targets such as for CAP inspections or participation in eco-schemes.

Through digital twins and integrated sensing, the AgriDataValue project shows how modern farms can move from reactive to proactive management. This transition not only improves operational efficiency but also strengthens environmental performance, supporting both farm competitiveness and CAP sustainability objectives.