FARMTOPIA

GAIA CASE STUDY 1

Supporting irrigation decisions in almond farming through GAIA

Project	GAIA - Cognitive Cloud Computing for Sustainable Almond Farming
Date	June 2026
Programme context	Farmtopia Open Call Sustainable Innovation Pilot
Location	GGS almond plantation, Salamanca region, Spain
Partners	Xilbi Sistemas de Informacion SL and Gregorio Garcia Sanchez
Focus	Agriculture and irrigation use case

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1. Executive summary

GAIA is an Agricultural Digital Solution developed to support more informed and sustainable decision-making in almond farming. The pilot is implemented at the GGS almond plantation in the Salamanca region, Spain, by Xilbi Sistemas de Informacion SL in collaboration with almond producer Gregorio Garcia Sanchez.

This case study focuses on irrigation decision support. Irrigation is one of the most relevant controllable factors in almond production. It affects water consumption, direct energy use, operating cost, crop development, production risk and the environmental performance of the farm.

Before GAIA, the farmer had access to several types of information, including field sensors, weather data, practical field knowledge and occasional geospatial or satellite-based information. However, these sources were fragmented. They were not available through a single workflow and were not automatically translated into clear operational guidance.

GAIA addresses this problem by combining field telemetry, weather data, Earth Observation indicators, AI-based recommendations and geospatial visualisation into one practical decision-support environment. The system helps the farmer review field conditions, understand irrigation-relevant risks, interpret recommendations and decide whether to act, adjust or override the suggested action.

The value of digital agriculture does not come only from collecting more data. It comes from organising data into a workflow that fits the farmer's real decision process.

2. Pilot context and irrigation challenge

2.1 Agricultural context

The pilot is implemented in an almond plantation in the Salamanca region. Almond farming in Spain is increasingly affected by water pressure, weather variability, operational cost and sustainability requirements. These challenges are especially relevant for farms that need to balance productivity with more efficient use of water, fertiliser, energy and labour.

In irrigated almond production, water management is a central operational issue. Too little irrigation can increase plant stress and affect crop development. Excessive or poorly timed irrigation can waste water, increase pumping-related energy use, contribute to inefficient fertiliser use and reduce the economic efficiency of the farm.

2.2 Fragmented data and decision complexity

Relevant information is often distributed across different systems and formats. Soil moisture readings may be available from field sensors. Weather forecasts may come from external services. The farmer may use local experience to interpret field conditions. Satellite data may provide useful vegetation indicators, but these are not always integrated into day-to-day farm decisions.

The practical problem is therefore not only the absence of data. It is the conversion of heterogeneous farm and environmental data into practical irrigation decision support.

At the pilot farm, irrigation decisions need to consider soil moisture evolution at relevant depths, environmental temperature, soil temperature, rainfall, rainfall probability, wind speed, vegetation status, parcel context, expected weather changes and farmer knowledge of local conditions.

Without an integrated workflow, the farmer must interpret these elements manually. This increases the time required to make decisions and can lead to inconsistent interpretation, especially when conditions change quickly.

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3. GAIA approach to irrigation decision support

3.1 Objectives of the use case

The irrigation use case is structured around six objectives: reduce data fragmentation; improve situational awareness; support irrigation-related decisions through clear AI-based recommendations; preserve farmer control; support traceability; and create a replicable workflow for comparable farms and permanent crops.

3.2 Digital components used

At field level, GAIA uses on-farm telemetry from existing sensors. These include environmental and soil-related measurements relevant to irrigation management. At data-integration level, the system connects external sources, including weather and Earth Observation data. At analytics level, AI-based models support irrigation-oriented recommendations and related advisory outputs.

At visualisation level, GAIA presents information through a dashboard, field-monitoring views and a digital twin. At interaction level, recommendations are presented in a concise and understandable format. The solution is designed for small and medium-sized farms and does not require a complete replacement of existing farm infrastructure.

3.3 Operational workflow

The workflow follows a simple sequence. The farmer opens the dashboard, reviews the field-monitoring view, checks relevant Earth Observation information, reviews the AI recommendation, decides whether to apply or adjust it, and preserves the decision and supporting context for later analysis.

- Review the dashboard to obtain a concise overview of farm and field conditions.
- Check the field-monitoring view to interpret measurements in spatial context.
- Review vegetation indicators and external weather information where relevant.
- Read the AI recommendation and the reason behind it.
- Follow, adjust or override the recommendation based on farmer judgement.

3.4 Human-in-the-loop design

GAIA is a human-in-the-loop system. AI provides support, but the farmer remains responsible for the final decision. This is important because agricultural decisions depend on local knowledge, field constraints, data quality and operational judgement. The system is not an autonomous irrigation controller; it is a decision-support layer.

4. Deployment experience and farmer feedback

4.1 Deployment at the GGS almond plantation

During the second implementation cycle, GAIA moved from prototype preparation into operational deployment at the GGS almond plantation. The deployment involved configuring the system for the farm context, connecting the relevant data sources, preparing the dashboard and field views, reviewing AI recommendation outputs and validating the workflow with the farmer.

The system was demonstrated in the operational farm environment, showing the main chain from field data and external data enrichment to dashboard display, digital twin visualisation and AI-based recommendation review.

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4.2 Feedback and usability lessons

Farmer feedback confirmed that the system must be practical, concise and aligned with real decision windows. The farmer does not need a tool that displays every available data point with maximum technical detail. The farmer needs to know what the field condition is, what the system recommends, why it recommends it and whether action is needed.

This feedback influenced the design of the dashboard and recommendation workflow. The system prioritises field status, practical recommendations and spatial interpretation. Explanations are included, but they must not be excessive. The objective is to support confidence and understanding without increasing the burden on the user.

4.3 Benefits observed at deployment stage

The benefits observed during deployment are mainly operational and qualitative. GAIA reduced information fragmentation, improved situational awareness, presented clearer decision support, improved transparency and created a stronger basis for later KPI assessment.

The final agronomic and economic impacts are still subject to consolidation. Water-use reduction, fertiliser-runoff reduction, yield effects, carbon-footprint reduction and operational-cost savings require sufficient validated farm-level records over the relevant agricultural period.

5. Impact pathway and KPI evidence status

5.1 Environmental pathway

The environmental impact pathway starts with better irrigation decisions. By combining soil moisture, weather, Earth Observation and field context, GAIA supports more informed decisions about when and how irrigation should be applied. This can reduce unnecessary watering and support better alignment between crop needs and water application.

More precise irrigation decisions can also contribute to reduced pumping needs and lower direct energy use. Improved field interpretation can support better timing of fertiliser-related activities, which is relevant for reducing runoff risk.

5.2 Economic and operational pathway

The economic pathway is linked to cost control and decision efficiency. Irrigation has direct and indirect costs, including water use, energy consumption, labour, equipment operation and field visits. When data sources are fragmented, the farmer may spend more time interpreting conditions or may decide with incomplete context.

GAIA supports economic value by reducing this fragmentation and helping the farmer prioritise action. The system provides a clearer basis for deciding whether irrigation is needed, whether conditions suggest waiting, or whether the situation requires closer monitoring.

5.3 Social and adoption pathway

The social and adoption pathway is based on farmer empowerment and trust in digital tools. GAIA addresses barriers to adoption by reusing available infrastructure where possible, presenting recommendations clearly and keeping the farmer in control.

5.4 KPI evidence status

The irrigation case study is linked to project KPIs including water use, operational cost, carbon-footprint reduction, fertiliser-runoff reduction, yield and yield production, farmer satisfaction and ADS acceptance.

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At this stage, GAIA has demonstrated operational readiness and farmer-facing value. Final KPI values must be reported only when the corresponding evidence is available. This distinction ensures that communication remains accurate and evidence-based.

Impact area	Targeted contribution	Evidence status
Water use	Support more precise irrigation decisions and reduce unnecessary watering.	Measurement requires final-cycle operational data.
Operational cost	Reduce avoidable water, energy and decision-effort costs.	Cost comparison pending complete farm records.
Farmer adoption	Increase usability, transparency and trust in digital recommendations.	Positive qualitative feedback collected during deployment.

6. Replication potential

The GAIA irrigation use case has replication potential in comparable agricultural contexts. The most direct opportunity is in almond farming and other permanent crops where irrigation management is a relevant operational challenge.

The replication model does not require every farm to have exactly the same configuration. The core pattern can be adapted to different farm structures and data availability conditions.

- Map the farm parcels and irrigation-relevant zones.
- Connect available soil and environmental sensors.
- Integrate weather and Earth Observation data.
- Configure AI-based recommendations for the crop and local conditions.
- Present outputs through a simple decision-support interface.
- Keep the farmer in control and preserve decision traceability.

The approach is also relevant for farm advisors, cooperatives and AKIS actors. Advisors can benefit from structured and authorised access to selected outputs. Cooperatives can use similar workflows to support knowledge transfer and promote more efficient resource use among members.

7. Conclusion

The GAIA irrigation case study demonstrates how an agricultural digital solution can support better-informed decision-making in almond farming. The pilot shows that the central challenge is not simply collecting more data. The challenge is converting fragmented data into a practical workflow that fits the farmer's decisions.

GAIA addresses this by combining field sensors, weather data, Earth Observation, AI recommendations and spatial context in one decision-support environment. The system has progressed from prototype concept to deployed and demonstrated ADS in the GGS almond plantation.

The final project phase will consolidate KPI evidence, refine the user-facing workflow and use the lessons from the GGS pilot to support replication in comparable farms and regions.

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