GAIA CASE STUDY 2

Integrating GAIA with Farmtopia reusable components for interoperable digital farming

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	Digital solution, interoperability and Farmtopia integration

Disclaimer

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.
© Farmtopia Consortium, 2023. Reproduction is authorised provided the source is acknowledged.

Contents

1. Executive summary
2. Interoperability challenge in digital farming
3. GAIA digital architecture
4. Farmtopia integration model
5. Operational outputs and technical evidence
6. Lessons learned and replication architecture
7. Conclusion

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101083541

1. Executive summary

GAIA is an Agricultural Digital Solution developed by Xilbi Sistemas de Informacion SL in collaboration with almond producer Gregorio Garcia Sanchez. It supports farm decisions by combining on-farm sensor data, weather information, Earth Observation, AI-based recommendations, cognitive cloud computing, a conversational decision-support interface and a geospatial digital twin.

This case study focuses on the digital solution itself and on its integration with Farmtopia reusable software components. The objective was not only to build a smart farming application for one almond plantation, but to create an interoperable, reusable and replicable digital workflow that avoids proprietary data silos and supports future adoption by comparable farms, advisors, cooperatives and technology providers.

The Farmtopia integration approach was structured around three main service areas: Digital Field Book alignment for farm records and traceability, Data Integration for external weather and Earth Observation data, and Data Exchange-compatible controlled sharing of selected GAIA outputs.

During Cycle 1, the work focused on architecture definition, sensor mapping, interface design, adapter preparation and Farmtopia-compatible data structures. During Cycle 2, GAIA moved from this preparatory stage to operational deployment at the GGS almond plantation.

The result is a working reference case for how an agricultural digital solution can combine local telemetry, external data, AI recommendations, digital-twin visualisation and controlled data sharing within an interoperable architecture.

2. Interoperability challenge in digital farming

2.1 Data silos and adoption barriers

Digital agriculture is increasingly data-rich. Farms may use soil sensors, weather stations, irrigation controllers, satellite services, field logs, advisory platforms and farm-management systems. However, these systems are often disconnected. Data may exist, but it is stored in incompatible formats, accessible through different interfaces, or locked into proprietary platforms.

For small and medium-sized farms, this creates several barriers: data fragmentation increases operational complexity; lack of interoperability increases integration cost; proprietary silos reduce long-term flexibility; poor traceability weakens trust; and disconnected systems make replication harder.

2.2 Requirements addressed by GAIA

GAIA had to ingest and organise farm-level data, integrate external data sources, support AI-based recommendations, display results through farmer-friendly interfaces, support controlled sharing and remain suitable for rural farm operation.

The solution therefore had to avoid creating a new isolated data silo. It had to connect the farm, external data services, AI outputs and authorised external consumers through a documented and maintainable architecture.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101083541

3. GAIA digital architecture

3.1 Hybrid edge-cloud model

GAIA is structured as a hybrid edge-cloud agricultural digital solution. At field level, the system uses the existing GGS sensor infrastructure, including soil and environmental data relevant to field monitoring and irrigation-oriented decision support.

At edge level, GAIA manages data transfer from the farm environment, including buffering, basic quality checks and resilience to rural connectivity limitations. At cloud and service level, GAIA processes data, connects external sources, runs analytics, manages APIs and supports the digital-twin and dashboard layers.

3.2 Data, analytics and interaction layers

At data-interoperability level, GAIA aligns records, observations and outputs with Farmtopia-compatible structures. At analytics level, AI models combine on-farm telemetry and external data to produce advisory outputs. At user-interface level, GAIA exposes the dashboard, field-monitoring view, AI recommendation page, digital twin and conversational decision-support interface.

At governance level, GAIA applies secure communication, role separation, access control and traceability. This architecture keeps the on-farm footprint limited while allowing the ADS to process and present more advanced data layers through cloud-supported services.

4. Farmtopia integration model

4.1 Digital Field Book alignment

The Digital Field Book is the Farmtopia component most directly linked to farm records and traceability. In GAIA, its role is to provide alignment for farm entities, field observations and operational records.

Relevant data categories include farm and pilot-site identifiers, parcel or zone references, crop and cultivation context, sensor assets, device identifiers, timestamped sensor observations, irrigation-relevant observations, recommendation outputs and related provenance.

4.2 Data Integration

The Data Integration path supports harmonisation of external weather and Earth Observation data. These data are used in the dashboard, field-monitoring view, digital twin and AI recommendation layer.

External data had to be requested through standard interfaces, associated with the relevant farm location or parcel, temporally aligned with sensor readings and handled consistently in terms of units, timestamps and measurement types.

4.3 Data Exchange-compatible controlled sharing

The Data Exchange-compatible layer was designed around selected outputs rather than unrestricted farm-data publication. Relevant output categories include observation summaries, recommendation outputs, KPI-relevant data and selected data products for advisory use.

The sharing model is designed to be read-only unless otherwise authorised. Access is based on secure interfaces, token-scoped authentication principles, role separation and traceability.

4.4 Semantic, API and security alignment

GAIA uses stable identifiers, Farmtopia-compatible data modelling, JSON-LD-compatible structures and REST-style APIs documented through OpenAPI/Swagger-style descriptions. Secure communication, controlled access and auditability are applied to protect farm-level operational data.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101083541

5. Operational outputs and technical evidence

5.1 User-facing outputs

The Farmtopia integration case produced several operational outputs: a deployed GAIA system in the GGS farm context; a dashboard combining telemetry, environmental information and decision-support access; a field-monitoring view; an EO-enhanced field view; an AI recommendation view; a digital twin; and a conversational decision-support interface.

5.2 Integration and diagnostic outputs

GAIA also includes a Farmtopia component configuration and status layer, an integration log system for traceability and troubleshooting, Swagger/OpenAPI-style API documentation and controlled sharing logic for selected outputs.

Diagnostic views are essential because integration behaviour must be visible. When a solution depends on sensors, external data sources, APIs and Farmtopia components, hidden failures can reduce trust and complicate deployment.

The logs record operational events related to Farmtopia component interaction, including connectivity tests, data-integration calls, weather retrieval, Earth Observation retrieval, parcel reading and correlation identifiers.

5.3 API documentation

The documented endpoints cover health checks, authentication, parcel data, sensor data, observations, irrigation recommendations, Earth Observation layers, digital twin configuration, KPI progress, dashboard summary and Farmtopia integration status.

This documentation supports internal development and testing, maintainability after the pilot, future connection with authorised services, and preparation of replication and partner onboarding material.

6. Lessons learned and replication architecture

6.1 Main lessons

The first lesson is that interoperability must be designed early. Entity mapping, identifiers, payloads and API contracts should be defined before deployment, not after the application is built.

The second lesson is that reusable components are most valuable when they support actual workflows. Farmtopia integration should improve how the farmer, advisor or developer works, not only satisfy a technical requirement.

The third lesson is that diagnostics are essential. Logs, health checks and configuration views reduce uncertainty during deployment and support trust in the system.

The fourth lesson is that farm-level data sharing must be controlled. Useful collaboration can be supported without exposing all operational data.

6.2 Replication architecture

The GAIA integration model can be replicated through a modular architecture: farm mapping, data-source connection, semantic alignment, external data integration, analytics configuration, user-interface configuration, controlled sharing, diagnostic setup, validation and replication documentation.

- Map parcels, plots, zones, sensors and relevant operational activities.
- Connect available sensors and external data sources through documented interfaces.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101083541

- Map farm and observation data to stable identifiers and JSON-LD-compatible semantics.
- Configure crop-specific analytics and user-facing dashboards.
- Expose selected outputs to authorised consumers through controlled sharing.

6.3 Relevance for ADS providers and stakeholders

The GAIA case is useful for other ADS providers because it shows how to integrate Farmtopia-aligned components without losing the specific value proposition of the ADS. The ADS provider can build crop-specific intelligence and user experience, while Farmtopia components support interoperability, data exchange and shared data principles.

The integration case is also relevant for farm advisors, cooperatives and AKIS actors. Advisors need reliable, structured and authorised access to farm information if they are to support decisions effectively. Cooperatives can use similar workflows to support multiple farmers with comparable crops or irrigation challenges.

Replication layer	Purpose	Practical output
Farm mapping	Identify parcels, zones, sensors and context.	Stable farm entities and identifiers.
Data integration	Combine local telemetry with external data.	Harmonised feeds for dashboards and AI.
Controlled sharing	Support authorised external use.	Read-only outputs for advisors or stakeholders.

7. Conclusion

The GAIA Farmtopia integration case study demonstrates how an agricultural digital solution can move beyond a single-purpose prototype and become part of an interoperable digital farming architecture.

The solution combines farm telemetry, external data, AI recommendations, digital-twin visualisation, conversational decision support and controlled data sharing. By aligning these elements with Farmtopia reusable components, GAIA reduces the risk of data silos and creates a clearer pathway for replication.

The Digital Field Book alignment supports farm-record traceability. The Data Integration path supports weather and Earth Observation data use. The Data Exchange-compatible layer supports controlled sharing with authorised consumers. REST-style APIs, OpenAPI documentation, JSON-LD-compatible structures, secure communication and diagnostic logs support maintainability and interoperability.

The final project phase will consolidate documentation, stakeholder evidence, dissemination material and the replication package, using the GAIA pilot as a reference case for Farmtopia-aligned digital farming solutions.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101083541