Digital technology assessment and demonstration toolkit, final at M48

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MIROSLAV BRABEC (CSITA), MICHAL STOČES (CZU), PAVEL ŠIMEK (CZU), EVA KÁNSKÁ (CZU),
DANIELE VERGAMINI (UNIPI), KATRINE SOMA (WR),
ARGENE SUPERINA (UL), SIMONA STOJANOVA (UL),
ALEXANDRA SINTORI (ELGO-DEMETER), ALEXIA GOBRECHT (INRAE), ANNA SELINI PETROPOULOU (AUA)

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DIGITAL TECHNOLOGY ASSESSMENT AND DEMONSTRATION TOOLKIT, FINAL AT M48

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Authors	Miroslav Brabec (CSITA), Michal Stočes (CZU), Pavel Šimek (CZU), Eva Kánská (CZU), Daniel Vergamini (Unipi), Katrine Soma (WR), Argene Superina (UL), Simona Stojanova (UL), Alexandra Sintori (ELGO), Alexia Gobrecht (INRAE), Anna Selini Petropoulou (AUA)
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Work Package Leader	AUA
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Project Coordinator	University of Pisa

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D7.9 Digital Assessment and Demonstration Toolkit – Version 1.0

History of changes			
Version	**Date**	**Changes**	**Authors(s)**
0.1	14.08.2026	Initial draft of D7.9 based on the D7.8 structure. Updated overall structure and introductory sections; MAT section rewritten to reflect the deployed tool and its technical implementation; EFC section extended with three additional Living Lab scenarios (Slovakia, Hungary and North Macedonia)	CZU, CSITA
0.2	28.08.2026	Update of individual assessment tools. Updated Database and Data Entry Tool, EFC, ECC and TAT sections to reflect progress in 2026 and the current status of tools available through the CODECS platform. Updated figures, descriptions of methodologies and tool functionalities	CSITA, CZU, UL, INRAE, ELGO-DEMETER, AGFT
0.3	07.09.2026	Integration of partner inputs and final tool information. Incorporated additional inputs from WP3/WP4 and tool developers; updated EFC Living Lab scenarios and their integration status; updated dataset inventory and MAT results; completed information on the Performance Demonstration Toolkit	CSITA, CZU, UL, INRAE, ELGO-DEMETER, AGFT
0.4	21.09.2026	Internal review version. Incorporated reviewers' comments; harmonised terminology and descriptions across EFC, ECC, TAT and MAT; checked figures, tables, links and references; editorial and formatting corrections; final consistency check against the CODECS platform	CSITA, CZU, UL, INRAE, ELGO-DEMETER, AGFT
1.0	29.09.2026	Final version for submission. All reviewer comments addressed; outstanding partner inputs incorporated; final editorial, formatting and consistency checks completed; document prepared for submission	Authors / WP7 team

CONTENTS

1 INTRODUCTION 3

2 DATABASE AND DATA ENTRY TOOL 3

2.1 Progress in 2026 3

3 ENVIRONMENTAL FOOTPRINT CALCULATOR (EFC) 3

3.1 Objective 3

3.2 Doppler Winery 4

3.2.1 Context 4

3.2.2 Process 4

3.2.3 Results 4

3.3 Gamota JR s.r.o. (Slovakia) – AIMS Artificial Irrigation Management 5

3.3.1 Context 5

3.3.2 Process 5

3.3.3 Results 6

3.3.4 Environmental footprint simulation 6

3.4 D&D Farm Kft (Hungary) – Innovative Soil Scanner (ISC) 6

3.4.1 Context 6

3.4.2 Process 6

3.4.3 Results 7

3.4.4 Environmental footprint simulation 7

3.5 Kievo Winery (North Macedonia) – RAMAS Farm Management Information System 8

3.5.1 Context 8

3.5.2 Process 8

3.5.3 Results 8

3.5.4 Environmental footprint simulation 9

3.6 Progress in 2026 9

4 ECONOMIC COST CALCULATOR (ECC) 10

4.1 Objective 10

4.2 Progress in 2026 11

5 TECHNOLOGY ASSESSMENT TOOL (TAT) 11

5.1 Progress in 2026 12

6 MULTICRITERIA ASSESSMENT TOOL (MAT) 13

6.1 Objective 13

6.2 Progress in 2026 13

7 PERFORMANCE DEMONSTRATION TOOLKIT 13

7.1 Objective 13

7.2 Progress in 2026 13

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TABLES

Table 1: Environmental footprint simulation scenarios – LL Slovakia (Gamota JR s.r.o., AIMS irrigation management)

Table 2: Environmental footprint simulation scenarios – LL Hungary (D&D Farm Kft, Innovative Soil Scanner)

Table 3: Environmental footprint simulation scenarios – LL North Macedonia (Kievo Winery, RAMAS)

FIGURES

Figure 1: Environmental Calculator, Life Cycle Assessment methodology (CODECS platform, screenshot July 2026)

Figure 2: Environmental Footprint Calculator, LL Slovakia (AIMS) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_SVK_AIMS.pptx, 24 July 2026)

Figure 3: Environmental Footprint Calculator, LL Hungary (Innovative Soil Scanner) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_HUN_ISC.pptx, 24 July 2026)

Figure 4: Environmental Footprint Calculator, LL North Macedonia (RAMAS) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_MKD_RAMAS.pptx, 24 July 2026)

Figure 5: Economic Cost Calculator, Costs/Benefits overview (CODECS platform, screenshot July 2026)

Figure 6: Economic Cost Calculator, NPV formula (CODECS platform, screenshot July 2026)

Figure 7: Technology Assessment Tool, overview (CODECS platform, screenshot July 2026)

Figure 8: Technology Assessment Tool, process infographic: inputs, framework, outputs, impact (CODECS platform, screenshot July 2026)

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1 Introduction

This report documents the database and data entry tool underpinning the CODECS platform, alongside four assessment tools for CODECS researchers and stakeholders to evaluate technologies and their impacts: (i) a technology assessment tool for users, (ii) an economic cost calculator, (iii) an environmental footprint calculator, and (iv) a multicriteria assessment tool. It also overviews the performance demonstration toolkit, integrating assessment outputs, developed in Task 7.5.

Target audience: tool developers, users, researchers involved in assessments, and other interested persons.

2 Database and Data Entry Tool

2.1 Progress in 2026

Since D7.7 (August 2025), the Database and Data Entry Tool (T7.3) has moved from a structural specification exercise into a live, publicly accessible instrument on the CODECS platform, built around the 'Inventory of Datasets' page. Across the ten months since the previous deliverable, the emphasis of this task shifted from designing the inventory's filtering logic – by sector (agricultural commodities, farming systems, legislation), data format (CSV, HTML, MP4, ODP, PDF, PNG, PPT, PPTX, TIFF, TXT), creator institution, and target audience (researcher, advisor, technology developer, farmer, policy maker) – to actually populating it in line with the FAIR principles set out in the project's Data Management Plan. As of 28 July 2026, the inventory still lists a single entry, 'SLO_LCA_Results' (INRAE, submitted 15 December 2025, Vineyards sector), unchanged since it was first checked for this deliverable on 16 July 2026. This reflects that data collection and ingestion from the 20 Living Labs is still in an intensive build-out phase, with WP3 and WP4 partners expected to progressively submit their own datasets as their interviews, focus groups and on-farm data collection activities are completed and cleared for publication.

For this final deliverable (M48), work on the Database and Data Entry Tool continues: the FAIR-compliant inventory build-out is ongoing, with additional datasets expected as WP3/WP4 partners complete and clear their Living Lab data collection activities.

3 Environmental Footprint Calculator (EFC)

3.1 Objective

The Environmental Footprint Calculator (EFC) is a web-based tool designed to assess the environmental impacts of digital technologies in agricultural production through Life Cycle Analysis (LCA). Its primary goal is to enable farmers, agricultural advisors, educational institutions, and policymakers to evaluate and mitigate environmental footprints by simulating scenarios and visualizing outcomes. By comparing agricultural processes before and after digitalization, the EFC provides actionable insights into sustainability, focusing on reducing impacts such as ozone depletion, marine acidification, and resource consumption. The tool supports storytelling through real-world use cases, such as the DOPPLER project in Slovenia, to demonstrate the practical benefits of digital technologies in agriculture. Since D7.8, the EFC's case-study library has been extended with three further pre-calculated Living Lab scenarios – covering Slovakia, Hungary and North Macedonia – each following the same LCA-based, before/after comparative structure as the Doppler Winery case. As published on the CODECS platform, the underlying LCA methodology is defined as a method for quantifying the material and energy flows associated with a product or service's life cycle, and assessing its potential environmental impacts "from cradle to grave" (Jolliet et al. 2016).

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Figure 1: Environmental Calculator, Life Cycle Assessment methodology (CODECS platform, screenshot July 2026)

3.2 Doppler Winery

3.2.1 Context

The Slovenian wine region faces significant challenges due to climate change, including rising temperatures, irregular precipitation, and soil degradation, all of which threaten sustainable viticulture. The DOPPLER project addresses these issues by deploying a network of digital sensors and cameras to monitor and optimize wine production, aiming to reduce environmental impacts while maintaining economic viability and improving social conditions for local communities.

3.2.2 Process

The EFC's application in DOPPLER follows a structured process:

1. **Sensor Deployment**: Soil, leaf, and water sensors, alongside high-resolution digital cameras, were installed across 15 vineyards in 2025. These sensors collect real-time data on environmental parameters, such as soil moisture, nutrient content, water quality, and canopy health.
2. **Data Transmission**: Sensors are connected to a gateway that relays data to a central server. The system uses secure, low-latency communication protocols to ensure reliable data transfer, even in remote vineyard locations.
3. **Analysis and Reporting**: The server processes incoming data using LCA methodologies, generating detailed reports on environmental impacts. These reports are visualized on the EFC's interactive dashboard, allowing users to explore metrics like carbon emissions, water usage, and energy consumption.
4. **Scenario Simulation**: The EFC enables users to simulate different production scenarios (e.g., adjusting irrigation schedules or reducing fertilizer use) and compare their environmental outcomes against a baseline non-digital scenario. This feature supports farmers in making data-driven decisions to optimize sustainability.

3.2.3 Results

The EFC's application in DOPPLER has yielded significant environmental benefits:

- **Environmental Footprint Reduction**: The digital scenario achieved an 18% reduction in overall environmental impact compared to non-digital methods, with specific improvements in ozone depletion

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(12%), marine acidification (10%), and water usage (15%). These gains are attributed to optimized resource management enabled by real-time sensor data.

- **Fuel Use Challenge**: Despite progress, fuel consumption remains a dominant contributor to environmental impacts, accounting for over 50% of the footprint in some scenarios. This highlights the need for further innovation in energy-efficient technologies.
- **Soil Degradation**: While the EFC has improved monitoring of soil health, degradation remains a challenge due to intensive viticulture practices. Ongoing work focuses on optimizing sensor placement to better address this issue.
- **User Adoption**: Feedback from Slovenian farmers indicates high satisfaction with the EFC's intuitive interface, with 85% reporting improved decision-making due to actionable insights from the dashboard.

3.3 Gamota JR s.r.o. (Slovakia) – AIMS Artificial Irrigation Management

3.3.1 Context

The Gamota JR s.r.o. Living Lab (Slovakia), coordinated by New Edu n.o., focuses on climate-resilient soybean production through optimised artificial irrigation. Irrigation management in the region is challenged by fragmented data systems and the need to align water use with environmental and policy requirements; the Living Lab's technological solution integrates soil-moisture sensor data, weather-station readings and irrigation databases into a single model to support precise, data-driven irrigation decisions.

3.3.2 Process

An algorithm developed for the Living Lab determines the daily irrigation dose from soil-moisture sensor and weather-station data, with readings stored and processed on data servers. As with the other EFC case studies, the environmental footprint of soybean production is assessed through Life Cycle Assessment (LCA, ISO 14040/14044), comparing a reference (non-digital) scenario against the digitalised scenario across the Environmental Footprint 3.1 impact categories. The digital technology itself – sensors, data transfer network and datacentre – is modelled in three tiers (hardware, network, datacentre) and added to the digitalised scenario's footprint.

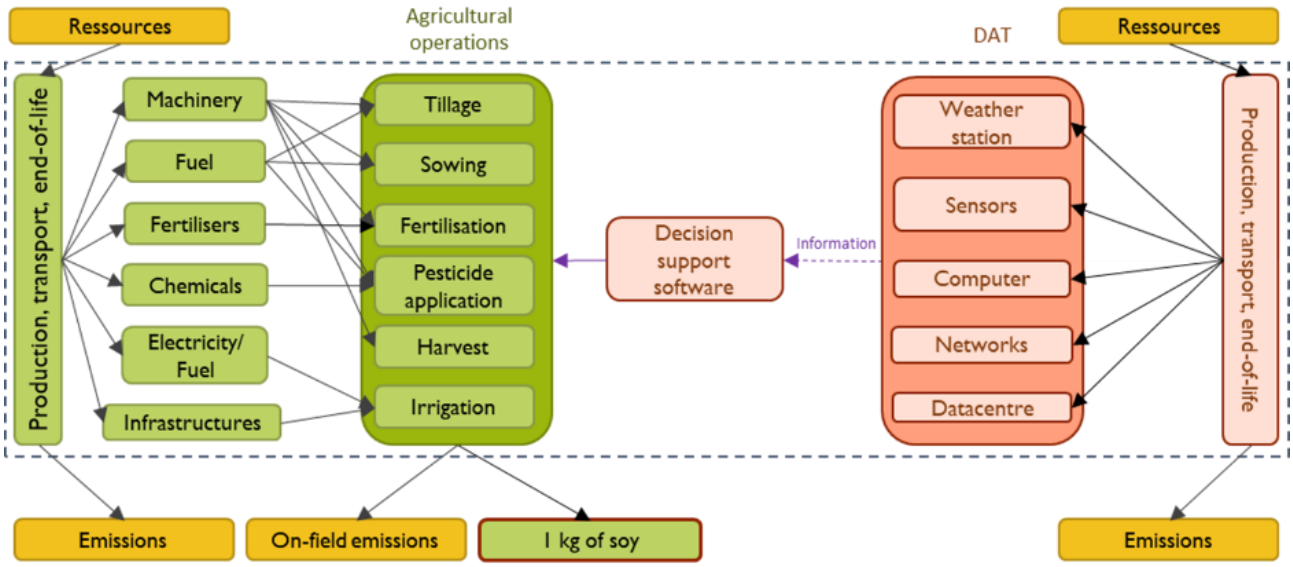

Figure 2: Environmental Footprint Calculator, LL Slovakia (AIMS) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_SVK_AIMS.pptx, 24 July 2026)

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3.3.3 Results

Across the impact categories assessed, the irrigation-management technology reduced the environmental footprint of soybean production by 7% to 21%, as more precisely timed irrigation raised yields (from 2,200 kg to 2,800 kg) without increasing other inputs.

The one exception is mineral and metal resource use, which increased by 27%, because the technology's own hardware, data transfer and – above all – data storage (98–99% of the digital technology's own impacts) add a footprint of their own. In the reference scenario, fertilisation and pesticide application remain the main hotspots, together driving the majority of impacts on climate change, human toxicity, acidification and eutrophication.

3.3.4 Environmental footprint simulation

Beyond the single reference/digitalised comparison, eight hypothetical scenarios vary the two parameters identified as most sensitive to digitalisation – irrigation volume (as a percentage of the reference quantity) and yield – while holding the rest of the digital-tool inventory constant. As with the other Living Labs below, this is a pre-calculated simulation, not an interactive calculator.

Table 1: Environmental footprint simulation scenarios – LL Slovakia (Gamota JR s.r.o., AIMS irrigation management)

Parameter	Set 1	Digitalised scenario	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
Irrigation (% of reference quantity)	100	100	80	60	40	80	60	40
Yield (kg)	2.200	2.800	2.200	2.200	2.200	2.800	2.800	2.800

3.4 D&D Farm Kft (Hungary) – Innovative Soil Scanner (ISC)

3.4.1 Context

The Innovative Soil Scanner Living Lab (Hungary) is run by Széchenyi István University in the Transdanubian region and tests a portable NIR soil scanner (SoilCares) for nutrient-management advisory in sunflower production. Actors involved span farmers, advisors, researchers, technology providers, input suppliers and policy makers, with a particular focus on young and female farmers and entrepreneurs.

3.4.2 Process

The portable NIR sensor measures macro- and micro-nutrients in the soil; readings are sent to a mobile app that generates a fertilisation recommendation for the farmer or advisor. As with the other EFC case studies, the reference (pre-digital) and digitalised fertilisation practices for 1 kg of sunflower seed are compared through LCA (EF 3.1), with the sensor, its data transfer and its datacentre storage modelled as an additional three-tier technology footprint.

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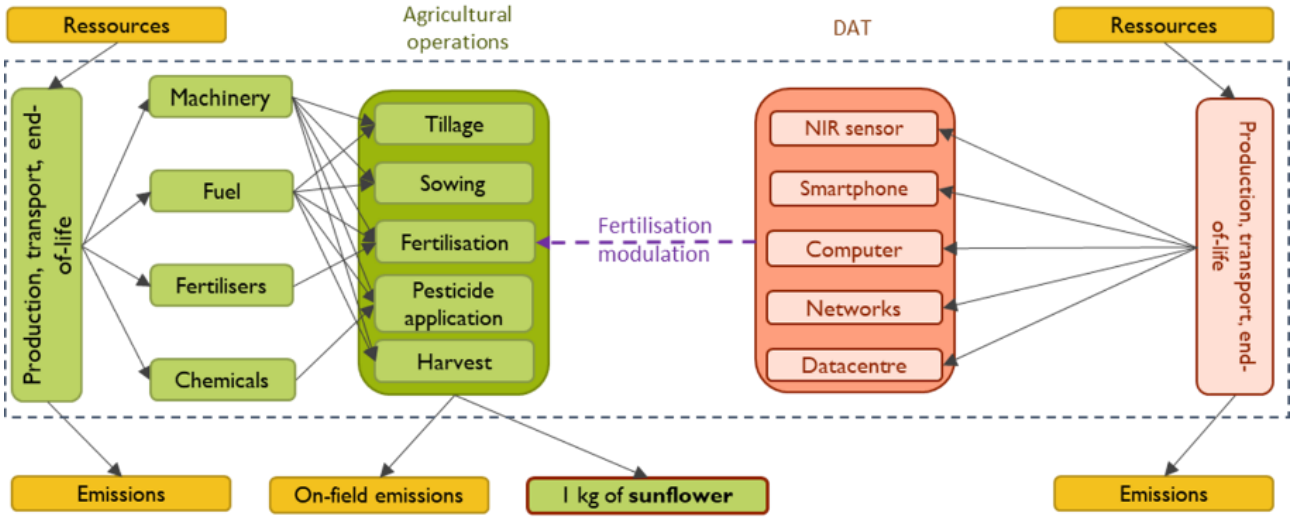

Figure 3: Environmental Footprint Calculator, LL Hungary (Innovative Soil Scanner) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_HUN_ISC.pptx, 24 July 2026)

3.4.3 Results

By identifying actual nutrient levels, the soil scanner allowed nitrogen application to be cut by 82% and the number of fertilisation passes to be reduced from three to one, which reduced the digitalised scenario's environmental footprint by between 1% (land use) and 63% (particulate matter) relative to the reference scenario. The scanner technology itself contributes only marginally to these impacts (0–6% of mineral and metal resource use), so – unlike the Slovak irrigation case – the gain is driven almost entirely by the fertiliser-input savings rather than being offset by the technology's own footprint.

3.4.4 Environmental footprint simulation

Nine hypothetical scenarios vary the quantities of the three fertilisers applied (as a percentage of the reference quantity) and the working time spent on machinery operations, isolating the two parameters identified as most sensitive to digitalisation for this Living Lab.

Table 2: Environmental footprint simulation scenarios – LL Hungary (D&D Farm Kft, Innovative Soil Scanner)

Parameter	Set 1	Set 2	Digitalised scenario	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9
Fertiliser 1 (% of reference quantity)	100	100	100	100	100	100	100	100	100
Fertiliser 2 (% of reference quantity)	100	50	0	100	0	100	50	50	0
Fertiliser 3 (% of reference quantity)	100	50	0	0	100	50	100	0	50
Work time (h)	0.41	0.245	0.08	0.16	0.33	0.285	0.37	0.12	0.205

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3.5 Kievo Winery (North Macedonia) – RAMAS Farm Management Information System

3.5.1 Context

The RAMAS Living Lab (North Macedonia), coordinated by AgFutura Technologies, accelerates digital transformation on small and medium farms and is demonstrated on the Kievo Winery demo farm in the Ovče Pole valley. RAMAS is a Farm Management Information System that centralises advisory data and farm-condition monitoring – in this use case fed by a connected weather station – to improve communication between farmers and advisors and optimise input use.

3.5.2 Process

Real-time monitoring and advisory recommendations from RAMAS support the farmer's decisions on pesticide and input use for grape production. The reference (pre-digital) and digitalised vineyard-management practices for 1 ha of grapes are compared through LCA (EF 3.1); the RAMAS technology – weather station, sensors, data network and datacentre – is modelled as an additional three-tier footprint, as in the other case studies.

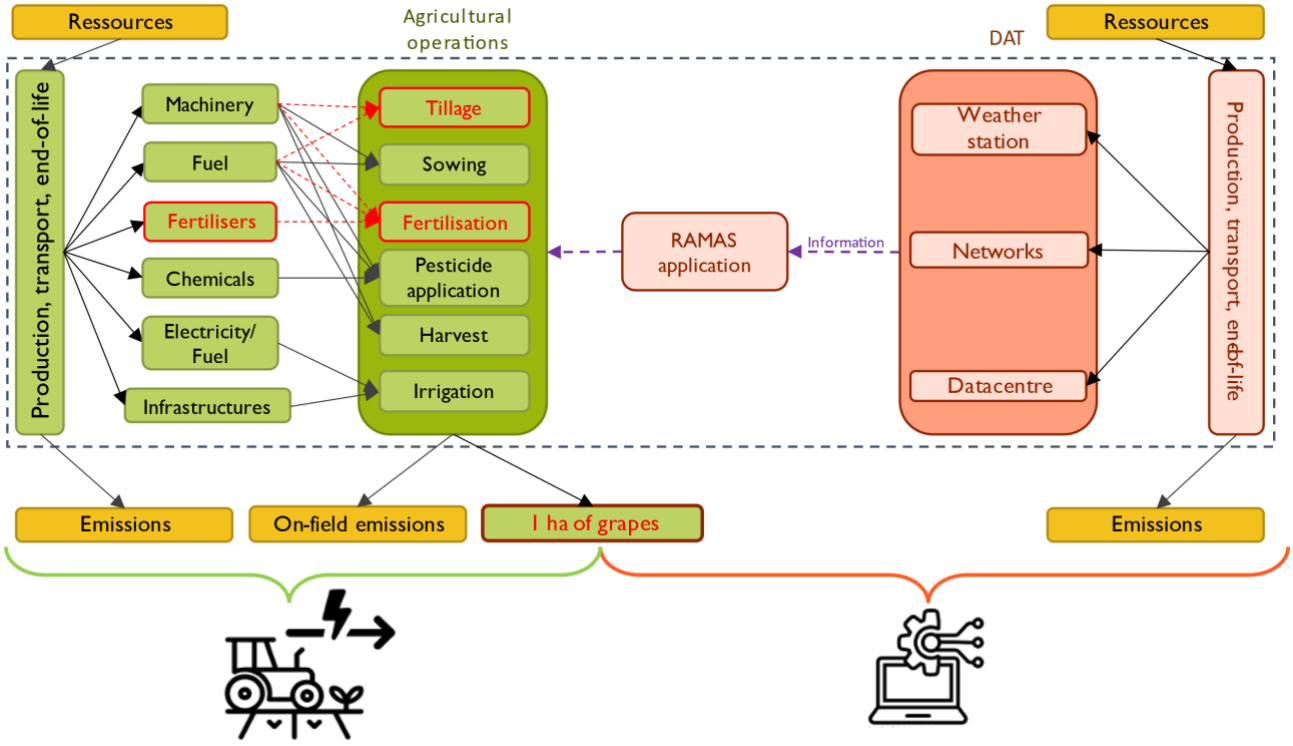

Figure 4: Environmental Footprint Calculator, LL North Macedonia (RAMAS) digital-scenario system boundaries (source: Baptiste De-Massé / INRAE, EFC_LL_MKD_RAMAS.pptx, 24 July 2026)

3.5.3 Results

Guided by RAMAS recommendations, the farmer reduced pesticide applications from eight to six, which lowered the digitalised scenario's footprint across all impact categories, from under 1% (land use) up to 24% (freshwater ecotoxicity – the category where pesticide application dominates the reference scenario's impacts). Fertilisation and tillage practices were left unchanged, so the categories they dominate – marine eutrophication, particulate matter, water use – saw smaller reductions (under 10%). As in the other two new case studies, data storage is the dominant

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contributor to the technology's own footprint (91–97%), though the reported negative water-use figure reflects a known modelling artefact in the underlying ecoinvent wastewater process rather than an actual water saving.

3.5.4 Environmental footprint simulation

Eleven hypothetical scenarios vary the quantities of the two pesticide applications identified as most sensitive to digitalisation – a fungicide/insecticide mix and a copper-based fungicide, each as a percentage of the reference quantity – together with machinery working time.

Table 3: Environmental footprint simulation scenarios – LL North Macedonia (Kievo Winery, RAMAS)

Parameter	Reference	Digitalised scenario	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10	Set 11
Pesticide X (% of reference quantity)	1	0	0.75	0.5	0.25	1	1	1	1	0.75	0.5	0.25	0
Pesticide Y (% of reference quantity)	1	0	0.75	0.5	0.25	0.75	0.5	0.25	0	1	1	1	1
Work time (h)	4	0	4	4	4	4	4	4	2	4	4	4	2

3.6 Progress in 2026

Over the ten months since D7.7 (August 2025), the Environmental Footprint Calculator – developed jointly by the University of Ljubljana and INRAE – has moved from a tool still described as being refined to a mature, largely complete stage, now published in full on the CODECS platform's Assessment Toolkit section. Its methodology is fully formalised, following the international standard NF EN ISO 14040 and the UN Environment Programme's Life Cycle Initiative, and structured around the four standard LCA phases – Goal & Scope definition, Life Cycle Inventory (quantitative process data collection), Impact Assessment, and Interpretation. It is presented through a clear before/after comparative approach, contrasting a reference (non-digital) process against the digitalised process to isolate the effect of technology adoption. Re-checked on 28 July 2026, the live platform confirms no material change to this description since it was first drafted on 16 July 2026: the EFC is now a finished, live resource for farmers, advisors, educational institutions and policymakers, rather than the work in progress it was still described as in D7.7.

For this final deliverable (M48), the Doppler Winery case study has been joined by three additional pre-calculated Living Lab scenarios – Gamota JR s.r.o. (Slovakia, AIMS irrigation management), D&D Farm Kft (Hungary, Innovative Soil Scanner) and Kievo Winery (North Macedonia, RAMAS) – received from Baptiste De-Massé (INRAE) on 24 July 2026 and forwarded by Anna Selini Petropoulou (AUA) for platform integration on 22 September 2026. Each follows the same LCA methodology (EF 3.1, ISO 14040/14044) and before/after comparative structure as Doppler, and each includes a set of pre-calculated 'what-if' scenarios varying the parameters identified as most sensitive to digitalisation for that Living Lab.

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4 Economic Cost Calculator (ECC)

4.1 Objective

The Economic Cost Calculator (ECC) is a decision-support tool designed to evaluate the economic costs and benefits of adopting digital technologies in agriculture. It aims to assist farmers, advisors, and policymakers by quantifying investment attractiveness, highlighting fixed and variable costs, projected savings, and return on investment (ROI). Through user-friendly interfaces and clear visualizations, the ECC supports informed financial decisions, with applications in business planning, academic research, and policy analysis within the CODECS project. On the CODECS platform, costs are broken down into categories such as new equipment and training, while benefits are captured as greater income and faster operations, feeding directly into the NPV calculation, which sums the present values of future net cash flows (benefits minus costs) over the investment period at a user-defined discount rate.

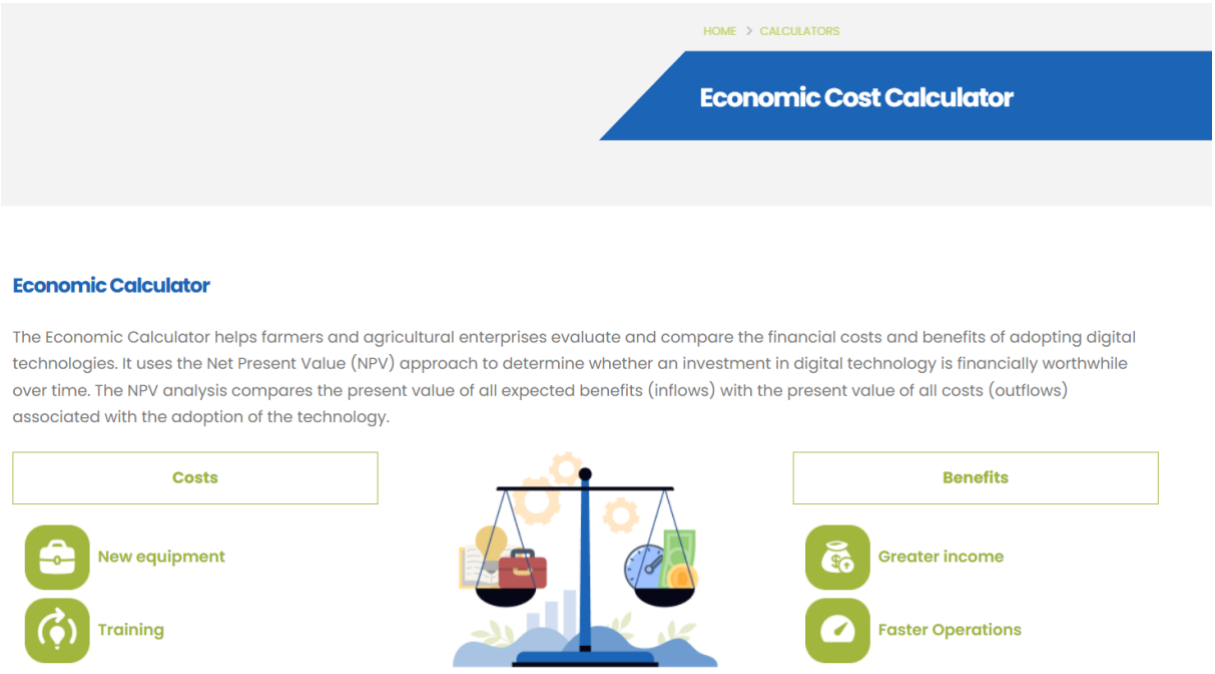

Figure 5: Economic Cost Calculator, Costs/Benefits overview (CODECS platform, screenshot July 2026)

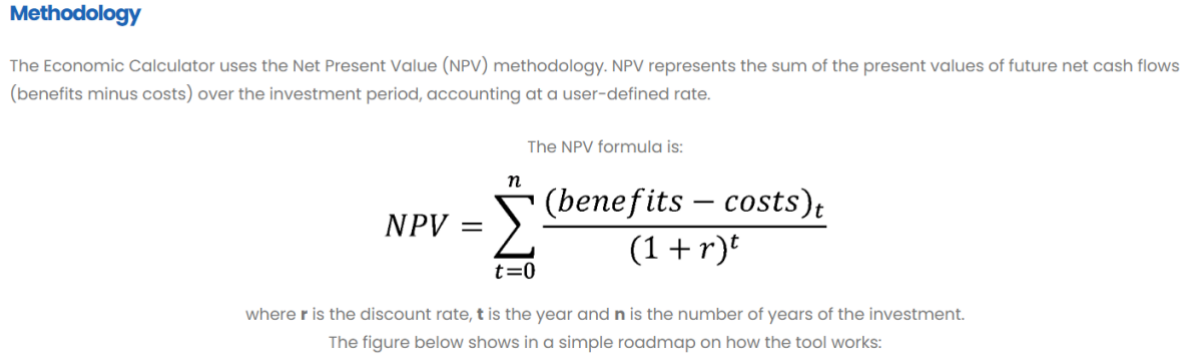

Figure 6: Economic Cost Calculator, NPV formula (CODECS platform, screenshot July 2026)

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4.2 Progress in 2026

Since D7.7 (August 2025), when scenario analysis and algorithm optimisation were still described as 'partially implemented, pending additional data', the Economic Cost Calculator – developed jointly by the University of Ljubljana and ELGO – has, over the intervening ten months, been completed and published on the CODECS platform as a fully structured, three-step decision-support workflow: (1) specify the investment, defining the technology and time frame; (2) calculate the Net Present Value, entering annual costs, benefits, the investment period and a discount rate; and (3) analyse the results, interpreting the outcome (NPV > 0 indicating an economically viable investment, NPV < 0 indicating it is not justified) and testing sensitivity by adjusting key variables. The underlying NPV formula, with its discount rate (r), year (t) and investment horizon (n) parameters, is now publicly documented, marking a move from the earlier partial implementation to a live, fully specified tool. This description was re-verified against the live platform on 28 July 2026, with no changes since the initial check on 16 July 2026.

5 Technology Assessment Tool (TAT)

The Technology Assessment Tool (TAT) operates at the business process level within the CODECS project, focusing on farm-level system thinking, including information flow, materials, technology properties, earnings, sales, and readiness in living lab settings. It enables farmers, agricultural experts, living lab representatives, and technology providers to evaluate the effectiveness of digital technologies through a structured, data-driven approach. By integrating expert-assigned impact scores (0-4 scale) and user-defined need scores, TAT ensures alignment with context-specific priorities, supporting decisions on technology adoption to enhance profitability and sustainability. Beyond CODECS, TAT is designed for scalability, with potential applications in extension agencies and commercial tools for transitioning to digital farming, incorporating advanced analytics for broader agricultural contexts. As published on the CODECS platform, the nearly 60 assessment criteria are organised into 7 key dimensions – technical performance, usability, data management, interoperability, economic impact, sustainability, and advisory value – each scored on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree".

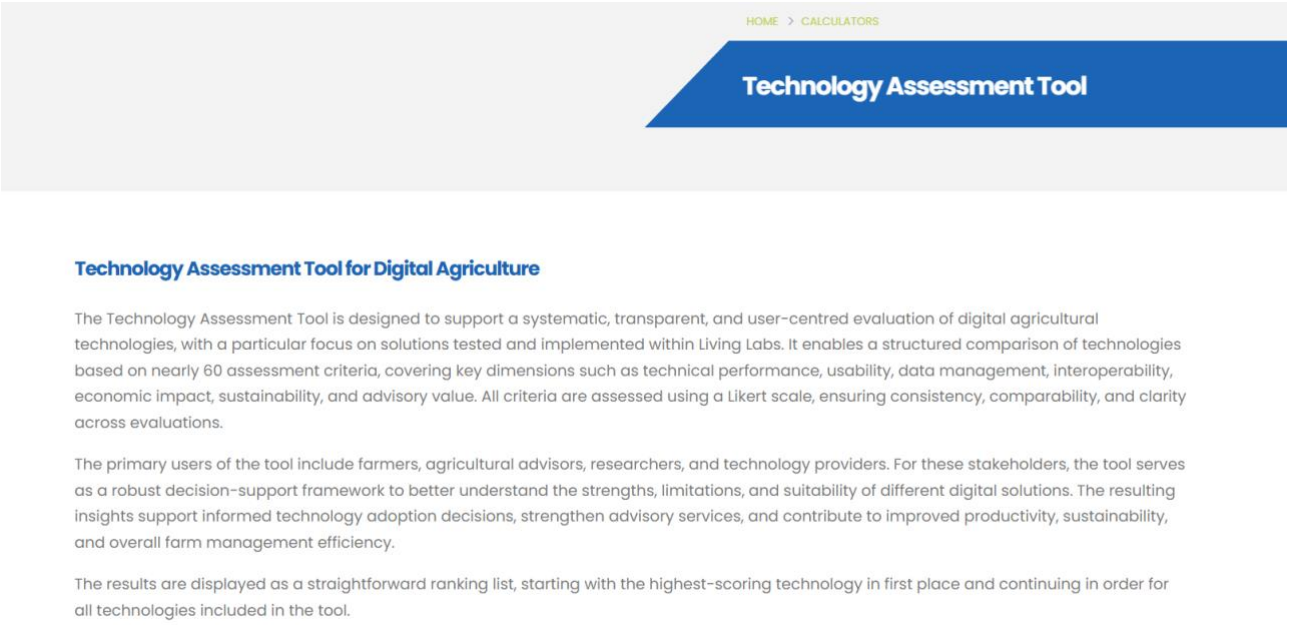

Figure 7: Technology Assessment Tool, overview (CODECS platform, screenshot July 2026)

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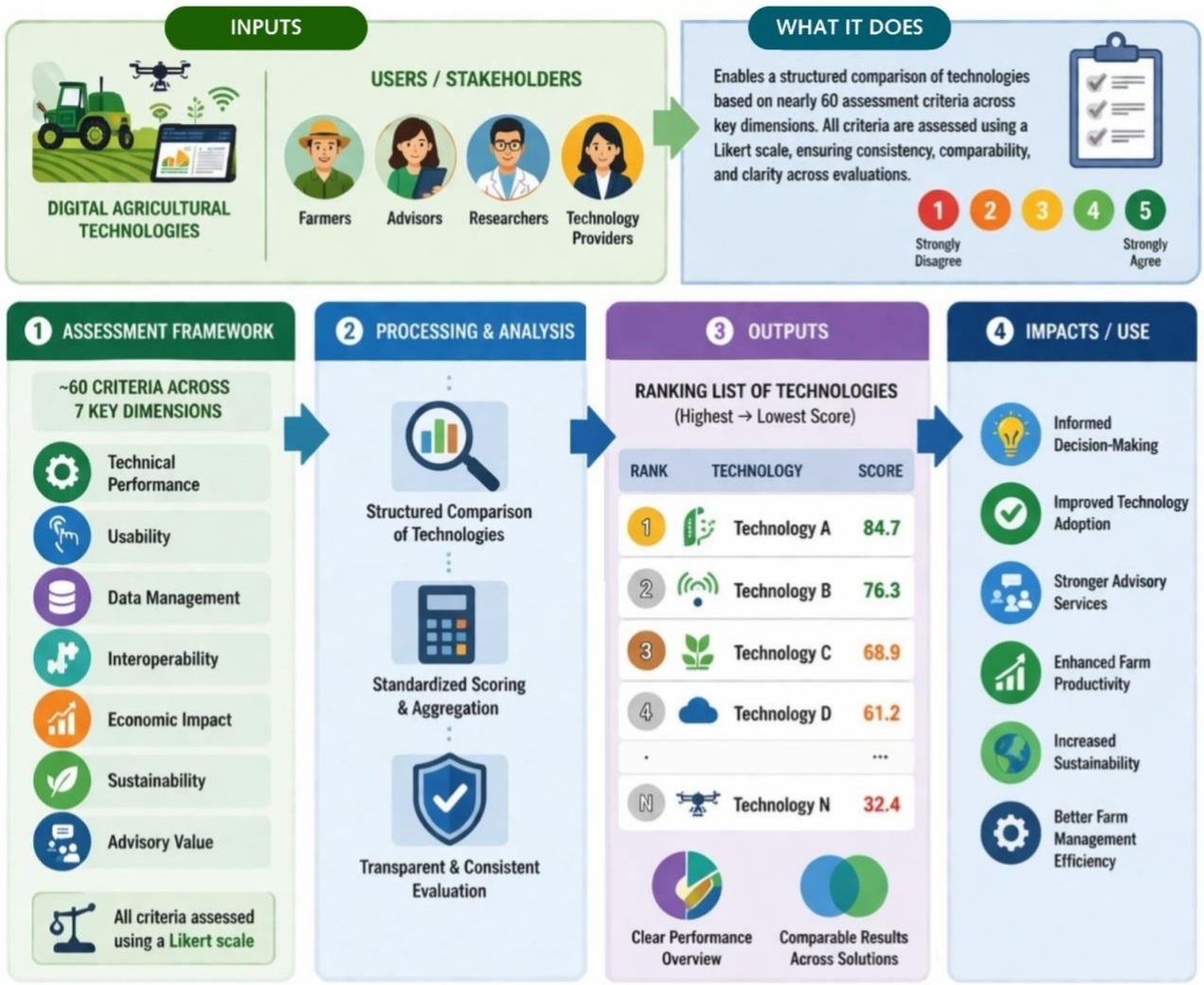

Figure 8: Technology Assessment Tool, process infographic: inputs, framework, outputs, impact (CODECS platform, screenshot July 2026)

5.1 Progress in 2026

Since D7.7 (August 2025), TAT – developed by AG FUTURA – has moved, over the ten months to this deliverable, from an internally-refined, FAIRSHARE-adapted framework into a fully deployed, public tool on the CODECS platform's Assessment Toolkit section. The criteria set has grown from 56 to approximately 60 evaluation criteria, still combining the Entropy Weight Method (EWM) – which assigns higher weight to criteria with higher variability across technologies – for criteria weighting, with TOPSIS for technology ranking, where the best-performing technology is the one with the smallest distance from the positive ideal solution. Scoring is now presented through a Likert-scale interface for consistency across assessors, and the tool targets the same broad user base as before – farmers, agricultural advisors, researchers and technology providers – delivering a ranked list of technologies as its output. This represents a clear step up from the FAIRSHARE-adapted, still-being-refined framework described in D7.7, positioning TAT alongside EFC and ECC as one of the tools that has moved from development into a live, publicly documented state. Checked again on 28 July 2026, the public page still does not display an exact technology or user count, so the 92 technologies / 75 users reported in D7.7 cannot yet be confirmed as current from the platform alone.

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6 Multicriteria Assessment Tool (MAT)

6.1 Objective

The Multicriteria Assessment Tool (MAT) employs Multicriteria Analysis to evaluate digital ecosystem scenarios for economic, social, and environmental sustainability, focusing on networks of digital, socio-economic, organizational, and physical elements that support digital technology and data utilization. It builds on CODECS' conceptual framework, particularly the Technology Assessment Tool (TAT) decision-making tree, to develop tailored criteria for assessing sustainability scenarios. The MAT targets stakeholders like digital ecosystem managers, policymakers, researchers, living lab coordinators, consultants, technology providers, and NGOs, enabling informed decisions through a sustainability scoring system based on indicators from living labs and TAT evaluations.

6.2 Progress in 2026

Since D7.8 (July 2026), the MAT – developed by CZU – has moved from active development into a deployed, publicly accessible tool: a web reimplementation of the CODECS MCA Tool V12 spreadsheet, live at https://codecs-mat-523870096382.europe-west1.run.app/. It covers 27 criteria across 3 dimensions, drawing on 290 individual assessments contributed by 9 Living Labs. Rather than the AHP/TOPSIS approach anticipated in D7.7, the deployed engine computes a pairwise 'robust' score (impact × certainty / 5) per criterion, applies dimension-level weighting, benchmarks each scenario with a fallback mechanism where data is incomplete, and produces a ranked list of scenarios – exposed to users through four modules (Analysis, Compare, Custom, Rankings). The application is a static single-page app (React, no backend); the source Excel workbook is converted via a migration script (migrate.py) into the JSON data and TypeScript types consumed by a pure-TypeScript calculation engine, validated by 93 automated tests across 11 test files, including a regression test reproducing the original spreadsheet's results to 10 decimal places. It is deployed to Google Cloud Run via CI/CD (lint, test, build, Docker build on every push to main and development branches; deployment only from main).

7 Performance Demonstration Toolkit

7.1 Objective

T7.5 delivers two complementary post-demonstration formats on the CODECS platform: interactive storybooks (audio-visual case narratives combining input from T7.2 and T5.4) and virtual tours (Virtual Reality video demonstrations of Living Lab farms). Both are published and publicly accessible via dedicated sections of the platform (digital-agriculture.horizoncodecs.eu/storybooks and /virtual-tours).

7.2 Progress in 2026

As of 28 July 2026 – re-verified against the live platform and unchanged from the initial check on 16 July 2026 – the platform hosts 7 interactive storybooks, covering: Consorzio Pecorino Toscano; the Agricultural University of Athens Experimental Farm; Living Lab Smart Villages Network, Slovenia; Living Lab RAMAS, North Macedonia; Living Lab LIT OUESTEREL; Living Lab Agrifood Technology; and Living Lab Greenhouse Smart Sensor Technology, Serbia – each combining a visual cover, an institutional identifier and a 'View' link through to the full narrative content. Alongside these, 5 virtual tours are published: Elchies Farm, Scotland; Bekas Nature Farm, Latvia; ILVO Farm, Belgium; Bromil Farm, Czech Republic; and AgDiBi Farm, Germany. The AgDiBi Farm tour reports that over 100 prospective farmers gained insight into digital technologies during its Smart Farming Field Day, illustrating the toolkit's reach beyond the CODECS consortium itself. Both formats have been consistently published and publicly accessible through dedicated sections of the CODECS platform throughout the reporting period.

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