



REFOREST

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Discussion Policy Paper #6

Digital Infrastructure, Data Governance and Decentralised Innovation for Agroforestry

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1. MOTIVATION / CHALLENGE

The evolution of European agricultural governance toward performance-based delivery is reshaping the role of digital infrastructure in farming systems. As the Common Agricultural Policy (CAP) moves toward measurable outcomes and as the Carbon Removals Certification Framework (CRCF) introduces monitoring, reporting, and verification (MRV) requirements, eligibility for public support and market recognition depend on credible, standardised, and interoperable farm-level data.

Digital infrastructure is therefore becoming a prerequisite for performance-based agricultural governance. The question is no longer whether digital systems should be used, but how they should be governed, financed and implemented in ways that remain transparent, equitable and accessible.

Agroforestry (AF) represents a specific challenge to performance-based delivery. AF systems combine trees, crops and livestock across long time horizons, generating outputs beyond conventional production metrics. Ecosystem services (such as carbon sequestration, biodiversity enhancement, soil functions, and risk buffering) are embedded within these regenerative systems but are not captured by existing administrative and valuation frameworks, creating a mismatch between public value creation and reward mechanisms.

Digital tools are often presented as an MRV solution to this mismatch, yet their uptake remains uneven. Skills gaps, concerns over data ownership, cost barriers, and distrust of opaque modelling approaches persist as systemic constraints. At the same time, the absence of shared data standards risks reinforcing fragmentation rather than improving coherence across schemes and certification systems.

This policy discussion paper¹⁸ examines how digital and decentralised innovation tools can be better integrated into EU policy frameworks. It draws on ReForest evidence and external research to assess the institutional, technical, and governance conditions required for digital systems to support agroforestry under a performance-based CAP post-2027 framework.

2. REFOREST EVIDENCE

Alongside the REFOREST engagement platform, four digital tools (see table below) have been developed within the REFOREST Agroforestry Toolbox.

2.1 REFOREST DIGITAL TOOLS

¹⁸ As part of the ReForest Policy Discussion series, this paper aims to support dialogue with panellists, gather targeted input, and help refine priorities for the final Policy Briefs to be released in June.

Dynamic management tool (University of Bonn – Germany)	This tool, based on a decision-analysis approach, supports farm decision-making by addressing the question: “What is the best agroforestry option given the current state of knowledge?”. It combines local and expert knowledge in a conceptual and probabilistic graphical model that links an input-output approach, while considering uncertainties around each of these components.
FarmTree (FarmTree B.V. – Netherlands)	The underlying mission of the FarmTree model and tool is to make AF investable. It does so by quantifying these systems’ outcomes. The model incorporates site information (species, plot location, management practices), a climate, soil and terrain model, and a species database. Its outputs are 10-50 year projections for AF indicators, including yields, cash flows, labour, and carbon.
Carbon and biodiversity prediction tool (Organic Research Centre – UK)	These tools help understand the impact of AF on soil carbon and plant diversity, although they have broader applications. They are based on neural network modelling applied to remote sensing imagery and are trained with large European datasets on soil carbon and plant species. In ReForest, the carbon tool was demonstrated on three AF farms in Europe, showing credible results. The apps can work on single coordinates or on batches of coordinates to create heat maps for fields or farms.
Public Goods Tool (University of Reading – UK)	The Public Goods Tool can be used to conduct a whole-farm sustainability assessment. It has been used for over 15 years, and the ReForest version is adapted specifically for AF systems. Across a range of environmental dimensions, entering data to a set of provided questions generates a score, visualised on a radar diagram to highlight the lowest-performing areas and therefore the priorities for improvement.

Table 5: Digital Toolbox. Source: Author’s Elaboration

2.2 REFOREST TOOLBOX

The Toolbox aims to support the decision-making of AF adopters by directing them to information relevant to their stage of thinking and specific questions. Within each of the sections (digital tools, case studies, knowledge hub resources), the material is presented within the lenses of:

- exploring the basics of agroforestry (before committing to implementation);
- financial considerations (the importance of identifying market opportunities and an outline of what needs to be considered in a cost-benefit analysis;
- environmental considerations (the farm level and wider environmental benefits of AF);
- practical considerations in relation to matters such as tree species choice, planting design, sourcing tree stock and capital items, establishment and management methods, and how these affect the overall economic potential.

2.3 LESSONS LEARNED

Providing immediate access to tools does not automatically translate into effective use.

In practice, expert support and training are often required. For example, FarmTree is most useful when accompanied by guidance, and the Public Goods Tool works best when a researcher or advisor enters data jointly with the farmer.

Some of the tools lend themselves better to use by consultants and advisors than by farmers and land managers as end-users.

This finding is corroborated by evidence from elsewhere. Many farmers lack the skills needed to engage effectively with emerging tools, especially smallholders and older demographics¹⁹. Conversely, digital agriculture is viewed as a mechanism for attracting younger generations back to rural areas²⁰.

Concerns over data privacy and ownership can also hamper data sharing.

More fundamentally, there can be a lack of trust in the reliability of tool outputs, especially when they are perceived as “black boxes” that convert input data into results without explaining intermediate steps. As one farmer remarked, “a fool with a tool is still a fool”; another questioned models with many variables and subjective assumptions that generate visually attractive graphs but may not be trustworthy.

Cost is another barrier. Tool development is expensive and often requires recovery through subscription models or paid services, which can deter uptake, particularly where expected benefits are uncertain or not recognised by support schemes.

EVIDENCE FROM THE REFOREST TRAINING AND UPSKILLING FARMERS WORKING GROUP

ReForest’s Training & Upskilling Farmers Working Group was set up to exchange insights from Living Labs across Europe and share practical experience on what makes AF training truly effective. The group is coordinated by ORC/ORC(ADAS) and has over 40 members. Alongside exchanges within the working group area on the stakeholder platform, the group has also held online meetings. Among the learnings from these exchanges, the group has highlighted the importance of:

- Farmer-to-farmer learning creates an open and practical environment where participants can compare approaches.
- Agroforestry learning is most effective when it is grounded in practical stories and lived experience.
- Training needs to be tailored to different audiences: advisors benefit from understanding the full range of AF options and system designs, while farmers tend to benefit most from training

¹⁹ Digitalising the EU agricultural sector. (n.d.). European Commission. Retrieved from <https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture>

Tur Cardona, T., Ciaian, P., Antonioli, F., Fellman, T., Rocciola, F., Ierardi, I., Crimeni, R., & Anastasiou, E. (2025). The state of digitalisation in EU agriculture. Publications Office of the European Union.

Smart Skills literature review: <https://smartskillsproject.eu/literature-review-en/>

²⁰ Ronzhin, A. et al (2025) Digital Transformation and Precision Farming as Catalysts of Rural Development. *Land* [10.3390/land14071464](https://doi.org/10.3390/land14071464)

that is local, practical, and closely aligned with their regional context.

EVIDENCE FROM TWO REFOREST WEBINARS

In a webinar about the *REFOREST* project on 28 October 2024, organised by Pasture for Life for the AFN Network+ (Agroforestry for Net Zero) winter webinar series, participants were asked to rank six forms of agroforestry advice and guidance by their effectiveness at different stages of the agroforestry journey. 17 respondents participated in the Menti survey. Five of them were farmers, but all – whether advisors, researchers, policy experts, or other stakeholders – were asked to put themselves in the farmers’ shoes.

The six advice/guidance options were:

- Farm walk-and-talk
- Visit of an advisor to their farm
- Living Lab or other networking activity
- Agroforestry handbook
- Tree species guide
- Digital tools, such as FarmTree and the Public Goods Tool.

For assessing how AF fits into their whole farm approach, and for understanding the practicalities of establishing and managing agroforestry, a farm walk-and-talk was the option considered most effective (ranked first or second by 70-85% of respondents). For designing a bespoke agroforestry system for their farm, the tree species guide came out top (65%, with the farm walk-and-talk a close second, most effective). For monitoring the performance of the agroforestry system, digital tools were by far the most effective option (85%).

In a ReForest webinar on *Digital Innovation for Scaling Agroforestry* on 18 February 2026, participants were asked: “What is currently the biggest challenge(s) you face when working with agroforestry?”. Among 22 respondents, over 50% indicated a lack of clear or comparable data; 50% highlighted uncertainty about costs, revenues, and long-term returns; 45% pointed to difficulties in measuring carbon, biodiversity, or public-goods outcomes; and 45% mentioned challenges in translating complex information into practical decisions.

3. LITERATURE REVIEW / EXTERNAL SOURCES

In a review of decision support tools (DST) for farmers in the UK published in 2016²¹, 395 tools were identified, of which 374 were digital (apps, software, Excel files, online). A survey of 45 farmers revealed 49% used some kind of DST to inform decisions, with modes of delivery being software (28%), paper-based (22%) and apps (10%). DST usage among advisors was significantly higher. The main factors in their usage were performance expectancy, ease of use, peer recommendation, trust, cost, habit, relevance to the user, and farmer-adviser compatibility.

²¹ Ronzhin, A. et al (2025) Digital Transformation and Precision Farming as Catalysts of Rural Development. *Land* [10.3390/land14071464](https://doi.org/10.3390/land14071464)

A study undertaken under the DigitAF²² The project explored the challenges in adopting agroforestry in Europe²³. A multi-stakeholder questionnaire was conducted across seven European countries to understand perceptions and needs for implementing agroforestry. Respondents used data and digital tools for various purposes in farming systems and were interested in their potential to improve agroforestry, including animal, tree, and crop performance, management guidance, system design, and tree species selection. Results revealed high perceived usefulness of digital tools but low awareness of existing ones, emphasising the need for accessible, user-friendly solutions and better promotion.

Key obstacles to agroforestry adoption included high initial investments, administrative burdens, concerns about reduced CAP support, and limited understanding of CAP support, requiring policy improvements and targeted support (including the use of tools).

Recent developments in artificial intelligence are adding a new dimension to digital agriculture. AI-enabled advisory systems, predictive analytics, digital twins, and generative AI tools are increasingly being explored to support farm planning, species selection, climate risk assessment, environmental monitoring, and decision-making. While these technologies may reduce information barriers and improve access to technical knowledge, they also raise questions regarding transparency, accountability, algorithmic bias and the concentration of data and analytical capacity among a limited number of technology providers.

A recently launched report by IPES-Food²⁴ warns of the dangers of digital innovations in agriculture being driven and controlled by Big Ag corporations rather than farming community stakeholders (at whose level REFOREST has been working within Living Labs). The report advocates strengthening public policy for responsible and just innovation, channelling research and funding towards sustainable, bottom-up initiatives, breaking up the power of Big Tech and Big Ag, and changing the narrative on innovation. “Innovation must empower farmers and serve justice, sustainability, and sovereignty – not deep dependency”. That is why REFOREST has focused on decentralised tools whose development has been informed by Living Lab co-design.

EURAF’s policy briefings underline these governance dimensions. In the context of CRCF implementation, EURAF stresses the need for workable monitoring approaches for agricultural soils and agroforestry (#20, #26). It also highlights the importance of linking carbon-farming parcels to LPIS systems to ensure traceability and consistency across Member States. In addition, EURAF points to inconsistencies in definitions and monitoring frameworks that complicate cross-country comparability (#15, #22).

²² In the DigitAF study, stakeholders (n=92) used digital tools for decision support (75%), research (37%), and training (23%). The data is also used in a wide range of thematic areas, including policy or subsidies (57%), tree and crop species selection (47%), economy or market (46%), and soil and nutrients (41%). Digital models are mostly used in technical or managerial aspects (40%). The preferred platforms for digital tools for agroforestry were tablets (33%), smartphones (59%), and laptops (75%).

²³ Tranchina, M. et al (2024) Exploring agroforestry limiting factors and digitalization perspectives: insights from a European multi-actor appraisal. *Agroforestry Systems* 98:2499-2515. <https://doi.org/10.1007/s10457-024-01047-x>

²⁴ IPES-Food. 2026. *Head in the cloud: challenging the false promise of digital agriculture and cultivating innovation from the ground up*.

These analyses converge on a common point: digital tools are not neutral instruments. Their effectiveness depends on standards, interoperability, advisory mediation, and clarity of regulatory frameworks. As performance-based governance expands, the challenge is less about tool availability and more about institutional coherence.

4. CAP POST-2027 IMPLICATIONS

The debate on CAP post-2027 points toward a stronger emphasis on measurable environmental performance. As policy discussions move toward clearer stewardship baselines and more outcome-oriented incentive structures, verification of results will become central.

In this context, digital monitoring and decision support systems gain importance. Where payments depend on demonstrated carbon, biodiversity or soil outcomes, farm-level documentation requirements increase. This raises questions about data standards, interoperability, and the consistency of verification across Member States.

The expansion of digital governance also raises important questions regarding data ownership, interoperability, transparency and sovereignty. Farmers are asked to generate data for public support schemes, certification systems, and sustainability reporting, yet the responsibilities and rights over that data often remain unclear. As digital systems become more central to agricultural governance, clear frameworks will be needed to ensure that data can be shared across platforms while protecting farmer interests and maintaining trust.

The expansion of performance-based schemes also carries institutional risks. Complex or fragmented monitoring requirements may disproportionately affect smaller farms. Unclear rules on data ownership, privacy and algorithm transparency may undermine trust and participation.

CRCF implementation reinforces these pressures. Parcel-level traceability, registry-based accounting, and sustainability compliance increase demand for structured, auditable data.

This strengthens the role of digital systems but also exposes gaps in coordination among CAP delivery mechanisms, carbon certification frameworks, and national reporting structures.

Emerging technologies such as distributed ledgers and decentralised verification systems are also being explored as mechanisms to improve traceability, transparency, and trust in environmental markets, although practical applications remain at an early stage of development.

The core challenge is institutional alignment. As agricultural governance becomes more data-intensive, the priority is not only tool development but the establishment of coherent standards, defined responsibilities and accountability mechanisms that prevent fragmentation and unequal access.

Digitalisation under CAP post 2027 will shape participation in performance-based schemes, the distribution of compliance costs and the overall transaction burden across farm types.

5. KEY QUESTIONS FOR THE POST-2027 CAP

- Whilst a large majority of EU farmers now use at least one IT or software tool, uptake of more advanced digital technologies remains lower among smaller farms and those with limited connectivity or digital skills. What can be done to make the advantages of digital agriculture more accessible and equitable across all parts of the farming community?
 - How can the tools be best applied to generate the data needed for EU policy formulation and to report on EU policy delivery and progress towards targets? With the wide choice of tools now available (some developed for specific countries and sub-regions), how can we improve comparability of the data that are generated and report confidently on targets from local to European scales?
 - What standards should guide the use of digital systems for Monitoring, Reporting, and Verification? How can MRV frameworks increase credibility and investor confidence without generating excessive certification costs or administrative burden?
2. How might digital traceability systems and decentralised finance mechanisms reshape agroforestry value chains? Under what conditions can verified environmental data strengthen market access without transferring disproportionate compliance costs to producers?
- Finally, what role should advisory systems play in mediating digital adoption? If digital tools are most effective when embedded in facilitated or advisory settings, how should AKIS structures evolve to ensure usability, trust, and accountability?
 - Who should own and control environmental data generated through public support schemes and certification systems?
 - Should the EU promote digital public goods and open standards to reduce dependence on proprietary agricultural platforms?
 - How can AI-enabled advisory systems be integrated into AKIS while maintaining transparency, accountability and farmer trust?
 - What role could decentralised verification technologies play in reducing the costs of MRV and environmental certification?

6. APPENDIX 1: REFERENCES AND RELATED DOCUMENTS

ID	Reference or Related Document	Source or Link/Location
1	DigitAF. (2024). Multi-stakeholder assessment of digital tools for agroforestry adoption across Europe. Agroforestry Systems.	
2	Digitalising the EU agricultural sector. (n.d.). European Commission.	https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture

3	IPES-Food. (2026). Head in the cloud: Challenging the false promise of digital agriculture and cultivating innovation from the ground up. International Panel of Experts on Sustainable Food Systems.	HeadInTheCloud.pdf
4	Ronzhin, A., et al. (2025). Digital transformation and precision farming as catalysts of rural development. Land.	https://doi.org/10.3390/land14071464
5	Rose, D., et al. (2016). Decision support tools for agriculture: Towards effective design and delivery. Agricultural Systems, 149, 165 174.	10.1016/j.agry.2016.09.009
6	Tranchina, M., et al. (2024). Exploring agroforestry limiting factors and digitalization perspectives: Insights from a European multi-actor appraisal. Agroforestry Systems, 98, 2499 2515.	https://doi.org/10.1007/s10457-024-01047-x
7	Tur Cardona, T., Ciaian, P., Antonioli, F., Fellman, T., Rocciola, F., Ierardi, I., Crimeni, R., & Anastasiou, E. (2025). The state of digitalisation in EU agriculture. Publications Office of the European Union.	10.2760/4688498 (online)