EIP-AGRI Workshop
Farm data for better
farm performance
FINAL REPORT
9-10 December 2021

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Executive Summary

The EIP-AGRI workshop "Farm data for better farm performance" took place on 9 and 10 December 2021. In the future, digital technologies and data-based solutions will continue to help farmers work more precisely, efficiently, and sustainably, improving decision-making and farming practices and helping increase farms' economic and environmental performance, whilst also making farming jobs more attractive to younger generations.

This interactive online workshop brought together the expertise and knowledge from public and private actors at EU, national and regional levels covering all relevant stakeholders involved in digital transformation of the agricultural sector. It aimed to: take stock of on-going successful projects and initiatives that collect and make use of farm generated data to improve farm performance; explore the role of the different stakeholders on-farm data collection at farms and their use for agricultural production; and provide an environment to exchange best practices on-farm data collection, use and sharing.

Through an interactive panel discussion, break-out sessions, a 'Project Market' and an 'Open Space', the opportunities and challenges regarding farm data use and the data solutions that can support farmers to enhance their farm performance were analysed and discussed. As a result of the discussions, the following further needs and knowledge gaps were identified:

Integrated data for better and more complex decision-making
There is an urgent need to integrate data from different sources and to scale up to create harmonised, easily accessible, quantitative and qualitative data sets. These sets are needed to take the step to interoperable digital solutions that support complex data driven decision-making.

Simplified, visualised and demonstrated data solutions for better use by farmers
Further exploration is needed with regards to how data handling and interpretation can be simplified, visualised, more easily accessible, better explained and more applicable at farm level. It is necessary to start from a real farming problem and to use data to solve it. More domain experts and IT experts should work together. Specialised advisors could become data interpreters and demonstrate both the cost and the benefits of data and its uses.

Two-way data flows to improve the value for all
Data should not stay on the farm but flow up the supply chain to create value. Farm data can help suppliers to show the sustainability of their production systems in a traceable way. The consumer values this information and appreciates transparency. However, it is also of upmost importance to bring data from outside the farm back to the farm. For instance, data from slaughterhouses, processors, suppliers, retail and even from the consumer, needs to flow back to the farmer in order to create value and support decision-making at farm level.

Integration of farmers' knowledge for improved digital services
To improve the algorithms for decision-making and to respond to the new and upcoming needs of farmers, it is crucial to take into account their practical knowledge and experience. Data and digital technologies should be used to do on-farm experimentation, to involve farmers in improving the algorithms and develop solutions on real farms. To involve farmers in this way, education plays a crucial role.

Exploring the cooperative model for trusted data sharing
Creating qualitative combined farm data sets should start at the level of individual farmers. Cooperative models and related business models for sharing and valorising data need to be further explored. The needs of small and medium sized farmers should also be considered. Farm data cooperatives, either built on existing cooperatives or newly created, have many advantages such as cost effectiveness and easier access to many data providers and data users while taking into account the regional perspective and the associated needs. They can also be the basis for (further) cooperation with researchers and can provide extra support for education, advice, testing and investments. But most importantly, data cooperatives can help to build trust.

1. Introduction

In 2006, Clive Humby, a well-known advisor on data strategy, said **"Data is the new oil."** He was referreing to the enormous potential that seems to lie in the possibility of generating large amounts of farm data, combined with other data and digital technologies. However, now, 15 years later, it is still challenging **to refine raw farm data** into **usable information, products and services** that can help increase farm performance. Farmers are increasingly using new technologies that gather and process data for delivering economic and environmental insights, but they rarely use the full potential of the data on their farms. Moreover, the data are generally not shared among farmers nor combined with other private and public data sources. This deprives farmers and other actors from valuable information generated by using "big data" or data technologies that can be applied on shared and combined data sets.

In the future, farmers will have to **manage their data in a smart way** by collecting, using and sharing data effectively to work more precisely, efficiently, and sustainably. The data is the basis for improved decision-making and better farming practices. It increases a farm's agricultural performance, whilst also making farming jobs more attractive to younger generations. At the same time, farmers must remain in control of their data, they need to decide what data to share, with whom and under which conditions.

The main challenges at farm level for farmers to unlock the full potential of data and data sharing for increased farm performance were discussed in depth in this EIP-AGRI workshop.

2. Introducing the participants and their projects

To ensure a dynamic process and a broad support of all stakeholders to the outputs and conclusions, the workshop balanced the representation of different profiles of participants. More than 100 participants from 28 countries joined the workshop. Eight percent of the participants were farmers, together with the farm advisors (11%) and the farm technology developers (15%), they represented over one-third of the participants, bringing practical knowledge about farming to the table. Another third of the participants belonged to the research community, while the last third included innovation support agents (around 15%) as 'innovation brokers' of knowledge and technical expertise, and other actors (19%).

Most participants represented innovative projects on the topic of the workshop. More than one fourth of the projects (28%) were EIP-AGRI **Operational Group projects (OGs)**. These OGs added value to the workshop because of their focus on solving real, practical and local farming challenges by co-creating innovative solutions with farmers, advisors, researchers and businesses. Representatives from **Multi-Actor research Projects (MAPs)** (27%) funded by Horizon 2020 or Horizon Europe added a cross border or an EU wide dimension and a stronger focus on research. **Thematic Networks** working on knowledge exchange across the EU represented 8% of the invited projects. Another large group (26%) was formed by environmental and climate projects funded under the LIFE programme, educational projects funded under Erasmus, INTERREG projects and also nationally and regionally funded projects. The remaining 11% of participating projects consisted of other innovative projects.

In summary, the workshop brought together the expertise and knowledge from public and private actors at EU, national and regional levels, **covering all relevant stakeholders for the digital transformation**, that were necessary to address the multifaceted topic of the workshop.
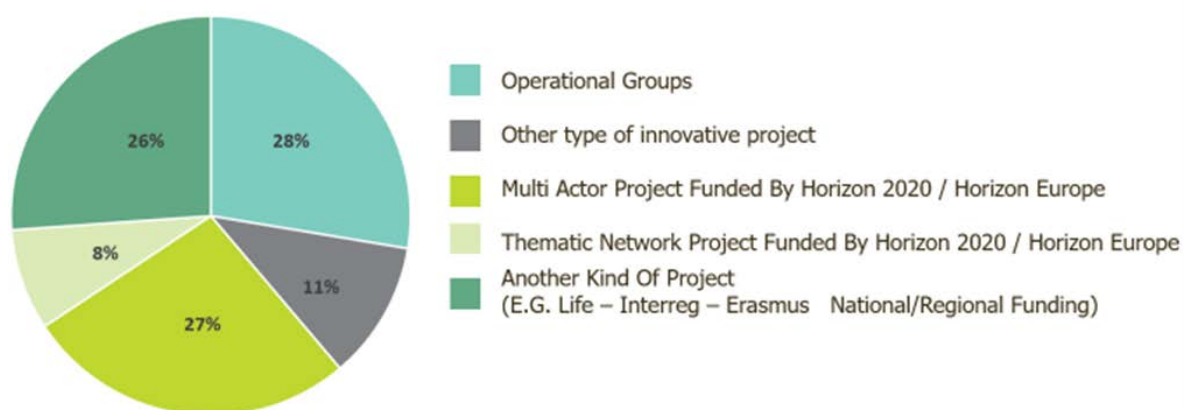
Figure 1: Registered participant projects

3. Opening of the workshop

Kerstin Rosenow (Head of Unit B2 – Research and Innovation, DG AGRI, European Commission) opened the workshop with a warm welcome to all participants. She invited them to look into ways to foster **innovation and knowledge exchange** in the framework of **farm data for better farm performance** by **exploring the needs** of individual farmers, researchers, advisors, and other actors. She explained that the workshop would provide a digital, interactive, multi-actor environment **to discuss the multiple perspectives**, with a focus on the **end user: the farmers**.

She further informed participants that the workshop would allow them to showcase their projects, share their challenges and solutions, and explore possibilities for future collaboration. In this sense, the workshop would also act as **a brokerage event**.

Kerstin Rosenow stressed the importance of the workshop in the **context of the digital transition** in Europe and explained that the European Commission is working on a digital transformation that will benefit everyone. In this regard, the workshop is an important event that contributes to Europe's digital future. Digital technologies have a high potential for impact on agriculture. Data driven tools contribute to improving decision-making, increase agri-environmental performance and competitiveness and add value to the agri-food chain. However, there are also some challenges to overcome. Kerstin Rosenow invited all participants to discuss these different perspectives.

4. Setting the scene

Jürgen Vangeyte (scientific director, ILVO) started by presenting some **overall trends in the agri-food sector**, divided into three main groups: people, technology and environment (Kirova et al., 2019).

Firstly, current **demographic developments** bring about the challenge of producing 50% more by 2050, while an ageing population combined with increasing urbanisation has an influence on the availability of the agricultural labour force and on the socio-economic situation of rural communities. The expected rise of incomes will be combined with changing consumption patterns and increased demands for processed food. **Technologically**, new innovations such as artificial intelligence, robotisation, automatisation, the use of earth observation data as well as breakthrough technologies like virtual reality are increasingly being used by the agri-food sector. The third very important component is the **environment** where climate change, environmental degradation, food loss and waste and scarcity of natural resources are challenging the way our food is being produced.

Besides these trends, Jürgen Vangeyte presented some other forces at play. **Trade agreements** impact food availability and distribution worldwide. Looking at the **economics of value chains** today, a large **globalisation and vertical integration** of business actors is taking place. This leads to concentration of power among bigger actors and creates a challenge for smaller stakeholders to participate. **Precision farming** is one of the main innovations in our current food production system, gradually more present in European farms. In addition, short supply chains and urban farming are growing, driven by an increasing demand for locally produced food. Thirdly, the **transformation of the marketplace**; the number of digital platforms both for data exchange between businesses (B2B) as well as between business and consumers (B2C) has been rising. Digital platforms foster transparency and efficiency, and also lead to horizontal and vertical collaborative partnerships within the agri-food chain (Paris Innovation Review, Agriculture and food: the rise of digital platforms).

The interaction between these different trends and forces brings forth three big challenges for the agricultural sector: **ensuring agricultural productivity, conserving land and water resources** and **guaranteeing safe, healthy and affordable foods**.

The European Union proposes a **green and digital agriculture** as an answer to these challenges. Sustainable improvement of rural economies and rural businesses will depend on the capacity to accelerate the digitisation and to develop the European knowledge economy. The European Green Deal clearly states that digital technologies, which help to produce farm data, are one of the critical enablers for reaching sustainability goals. The Farm to Fork strategy further clearly recognises that a green and digital transition in farms is needed to boost the farm performance. The question is: how can digital technologies and solutions that create farm data help? To reach the sustainability goals a shift toward **smart farming** is absolutely necessary. This approach, using the digital technologies and data-based solutions, starts with sensing and monitoring, followed by analysis and planning and, as a third step, smart applications (Pesce M. et al., 2019). The engine of this process is powered by the farm data that improves farm performance by enabling the farmer to make more precise and effective, and therefore more sustainable, decisions on the farm.

In 2015, EIP-AGRI embarked upon a journey towards digital farming with the EIP-AGRI Focus Group on Precision Farming. It also organised the EIP-AGRI seminar 'New skills for digital farming' in 2020. This trajectory has helped to identify some important needs: (1) **farmers and cooperatives** should be more **involved** in the R&I process; (2) **advisors** are needed **with the right supporting tools** to provide adequate training for farmers; (3) a **clear cost-benefit analysis** is crucial; (4) **more attention** should be paid **to small and medium farmers**. Furthermore, there is a need for: (5) **regional approaches**, (6) further **technical improvements** of digital solutions, (7) **interoperable** solutions that are **tested and validated in practice** for quick adoption, and (8) tailored sustainable **business models** that are tested and demonstrated.

A lot of these needs have been addressed within many research and innovation projects and Operational Group projects. Specific initiatives, like the Smart Agri Hubs have been deployed to integrate **regional customised approaches** in the co-creative design of digital solutions. The involvement of farmers and advisors has greatly improved, and technical and interoperable solutions have been demonstrated with their business models. There is still some work to be done on **interoperability and the involvement of small and medium sized farmers**. Furthermore, **adoption is still too low** and most of all, the **cost-benefits** are still not clearly demonstrated to the farmers.

There are some important challenges ahead of us. First of all, farmers need further support on how to **evaluate the benefits** of using farm data, and specifically medium to longer term benefits. It is not always very clear for farmers what these potential longer-term benefits are and when they can be expected. Secondly, farmers need **more fairness**. Farmers argue that they already invest a lot in digital technologies and that sometimes the return on these investments is made outside the farm. Furthermore, many farmers feel like they are contributing daa, but there is no or not enough value coming back. Real improvement will only be possible if there is **trust between actors** who share and work with the available data. In order to overcome these challenges and to better evaluate benefits, to assess the fairness and to trust the digital exchange of data, there is an overall need for **more digital skills**, and for better capacities to make the investments in digital technologies.
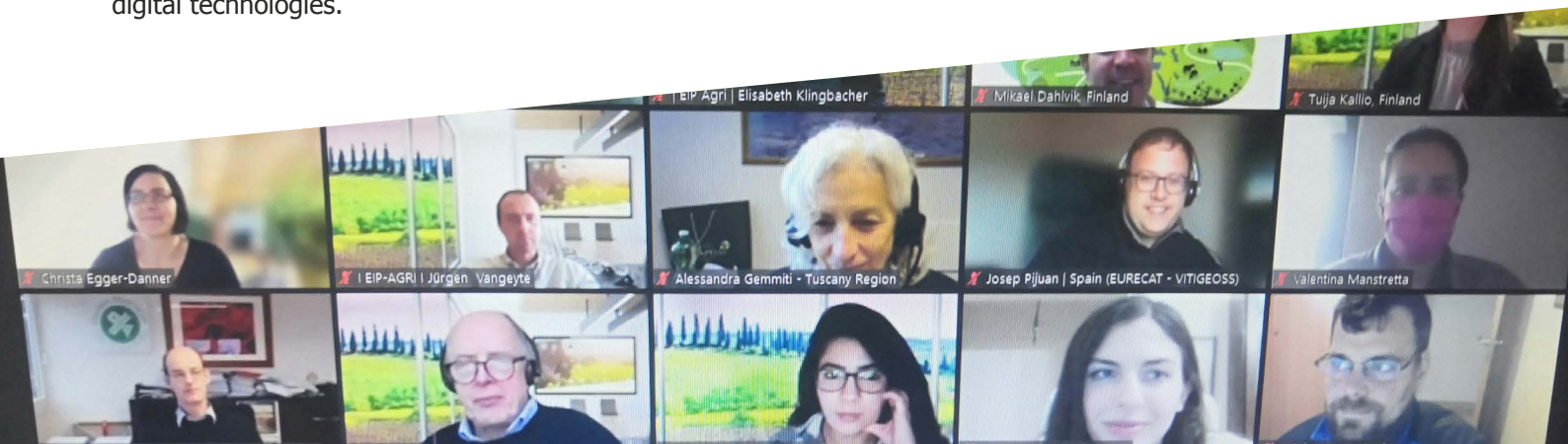
Doris Marquardt (Unit B2 — Research and Innovation, DG AGRI, European Commission) explained that the intention of the workshop is to share information about inspirational initiatives and **good practices** that **collect, share, use and reuse farm data** for improving farm performance. It should also help to build **understanding** on **the role** of the farmers, the advisors, the data intermediaries and platforms and other different stakeholders in collecting, sharing and using farm data. Existing cooperatives and other models of association and governance to create information from data will be explored. She also underlined the interest towards **joint problem-solving** to discover solutions that can be transposed from one region to another. Finally, the exchanges at the workshop would also further build the **networking and collaboration** opportunities within the broad EIP-AGRI community.

She explained that the results of the workshop will go **beyond the EIP-AGRI community**. The new **Horizon Europe Programme** would benefit from the identification of knowledge gaps, research needs or the generation of new proposal ideas. Furthermore, the development of the testing and experimentation facilities in the **Digital Europe Programme** could get inspiration from the challenges and issues that were to be discussed in this workshop. In addition, the upcoming **network of European Digital Innovation Hubs** in agri-food can integrate the challenges or innovations emerging in this workshop. Finally, in the framework of the Common Agricultural Policy (CAP) the results of the workshop may give input to further tailor AKIS (Agricultural Knowledge and Innovation System) interventions. Last but not least, the innovative ideas brought forward at the event, could inspire the national **CAP strategic plans** regarding the challenges to be addressed in digitalisation strategies.
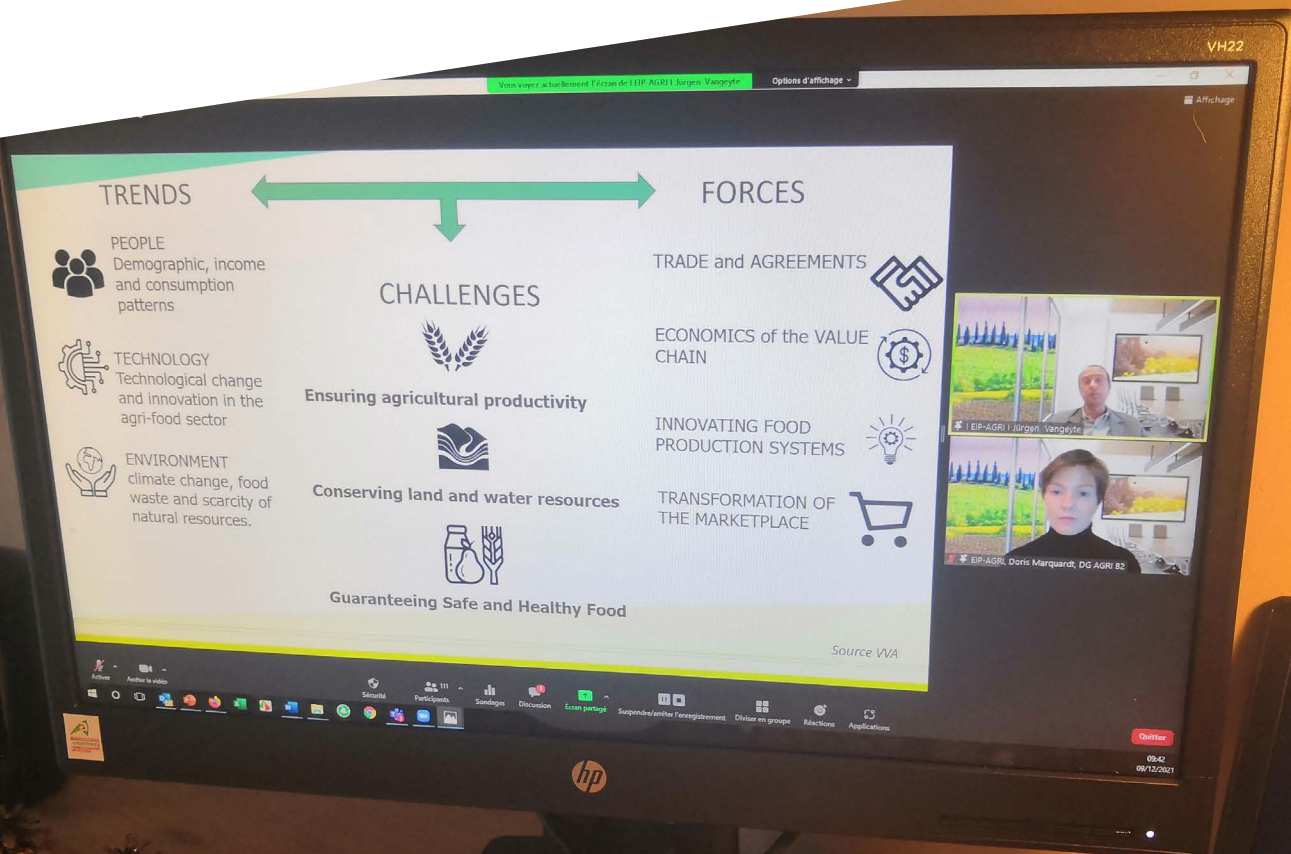
5. Interactive panel discussion with inspiring examples

5.1 Inspiring videos

To introduce the panel discussion, six inspiring videos of existing farm data initiatives beneficial for farm performance were shared and can be found here: https://ec.europa.eu/eip/agriculture/en/event/eip-agri-workshop-farm-data-better-farm. The panel was made up of representatives from the following projects:

Anna-Carin Almqvist, Sweden, Better decisions for cultivation strategy, OG

This OG creates a digital service for farmers, advisors and researchers where data from seven years of field trials are made available and merged with other data to increase knowledge and competitiveness amongst farmers in Sweden. The service is built on farm-related data entered by farmers and other users, plus additional data such as weather and geological data. For farmers and advisors, business value is created through well-founded decisions.
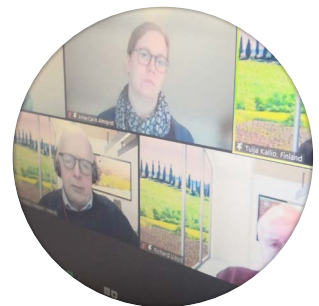
Stéphane Volant, France, IoT CUMA, OG

Through CUMA (Cooperative for the use of farm implements), farmers own and operate farm agricultural machinery collectively, making it both more affordable and more efficiently utilised. This OG from Normandy, France, uses the Internet of Things to collect data from on-board telemetry and GPS counters on the machinery being shared to fully automate how they determine the proportion of use by each CUMA member and the invoicing process. This saves a tremendous amount of time and lowers the administrative burden, for both the farmers and the cooperatives. In the next phase, the data will also be used to advise farmers on how to optimise machine use efficiency and assess machine performance.

Richard Lloyd, UK, 4D4F, Horizon 2020

4D4F (Data Driven Dairy Decision For Farmers www.4d4f.eu) highlights the need for research on integration of multiple sensors and data into one system to provide real-time information and recommendations for actions for farmers. Basing decisions on combining sensor data with management data allows for the implementation of standard operating procedures that can automatically contextualise the health alert of individual cows.

Sensor information combined with a comprehensive farm management information system (FMIS) which records management actions and animal parentage, opens new possibilities in sustainable genetic improvement, making livestock farming more efficient and profitable. In addition, longer living, more productive cows have a lower carbon footprint. In conjunction with a future ability to breed for lower methane emitting cows, sensor data will have the potential to become the ultimate tool in dairy farming sustainability. Furthermore, sensor data can also improve the quality of life of those who work on the farm.

Tuija Kallio, Finland, SMARTFEED, OG

The OG has developed a silage dry matter monitoring system that includes a semi-automated silage sampler attached to the farm equipment, on-farm applicable dry matter measurement tool and an app to accurately optimise feeding on a daily basis. The mobile app has data storage and user control, and it calculates the total mixed ration (TMR) recipe based on the entered dry matter (DM) values.

The system decreases the labour and time needed for dry matter monitoring and delivers better profitability for the farm by more accurate feeding.
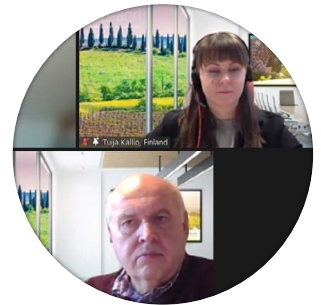
Tom Kelly, Ireland, FAIRSHARE, Horizon 2020

The FAIRSHARE project (www.h2020fairshare.eu) helps farmers with the digitalisation of their farm businesses. The project has set up an inventory of digital tools for advisors that can be used in their interactions with farmers. An example in Ireland is the digitalisation of animal identification systems, which supports farmers in their decision-making process and in benchmarking farm performance. It also allows advisors to have direct access to updated information with the approval of the farmers.
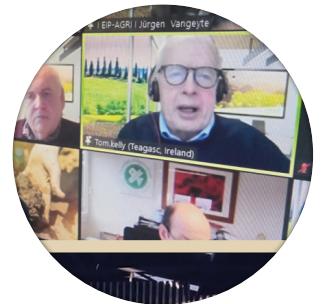
Jose Pedro Salema, Portugal, Portuguese irrigation portal for farmers

The irrigation portal offers basic services to farmers such as listing their plots, water readings and consumptions and payment status. The available data is integrated with European Sentinel data, offering several indicators for each plot such as normalised difference vegetation index (NDVI) and water stress. The portal is used for advanced digital services like weather forecasting, irrigation advice, simulation of land suitability and comparison between estimated values and the volume of water actually consumed for farmers' individual crops. Farmers can evaluate the efficiency of water use in cubic meters per hectare and euros per cubic meter. They can consult and use their own energy profile and take management decisions for watering at times when the cost of energy is lower and therefore save costs.

## 5.2 Questions and discussion with the panellists and the participants

The panel had a very lively interaction with the participants, who asked a variety of questions to the panellists. Participants were interested to understand **how the members** of the IoT CUMA OG **adopted** the automated counters for machine use and the fully automated invoice system. It was clarified that, although adapting the existing system to the new way of working took quite some time, what convinced the members to use the new system was the realisation that it **saves a lot of administrative costs**. As a next step in the project, the value of the digital solution will be further increased by also delivering **decision support** to the members. Farmers will be invited to work with the data, starting from easy Excel files and supported by tailored training on digital skills.

There was an agreement among the participants that **delivering added value to the farmers** is of key importance. It was mentioned that the Portuguese Irrigation Portal for farmers also works towards that goal. Small farmers need irrigation advice to improve irrigation efficiency. More added value could be delivered by installing sensors between the crops in the fields and by **sharing that information with all farmers**. This would be a perfect example of **combining private and public data** to develop a service for farmers. Farmers will also get access to the sentinel hub information so they can get a kind of 'zoom-in'" on their farm with the relevant information for **decision support**.

When discussing the added value of farm data, it was brought to the table that valuable data driven applications should also focus on how to **control and secure the data**. Experience from 4D4F showed that, although it is very important that farmers benefit from the value of their data, they **do not have time to market their data**. They need a trusted partner as an intermediary who can do that, under conditions set and agreed upon by farmers. Companies trying to develop new services from the data cannot contact farmers one by one for their data. Therefore, a data intermediary or a platform could be beneficial for both the farmers and the companies. SMARTFEED paid attention to the issue of security and used **access control** to guarantee appropriate access to the data.

The link was made with **cost-benefit analysis of digital solutions**. The question was raised whether farmers take up technology based on a **clear cost-benefit analysis** or reasonable payback times. It was explained that the application, proposed in the SMARTFEED OG, to accurately optimise daily feeding, is very clear on its economic benefits. The rural advisory services calculated that in a 100-cow herd, a saving of 500 euros per month can be made by optimising the daily feeding.

Looking at dairy farming for example, technology for heat detection delivers much higher fertility rates and replaces the need for 24-hour surveillance. Therefore, the technologies are largely taken up because it is **easy to quantify the benefits**. However, quantifying the health benefits is much more challenging. Indeed in this case, about 80% of the benefit for farmers using health sensors is actually in the increased milk production that they are able to gain due to earlier disease detection and healing. The direct treatment costs and the milk they are throwing away is much more visible to the farmer although it only represents 20% of the benefit. It is difficult to make **general assumptions regarding the return on investment of technology**. Tailored solutions can be provided by identifying the specific challenges of each farm and addressing these by technologies adapted to the specific situation.
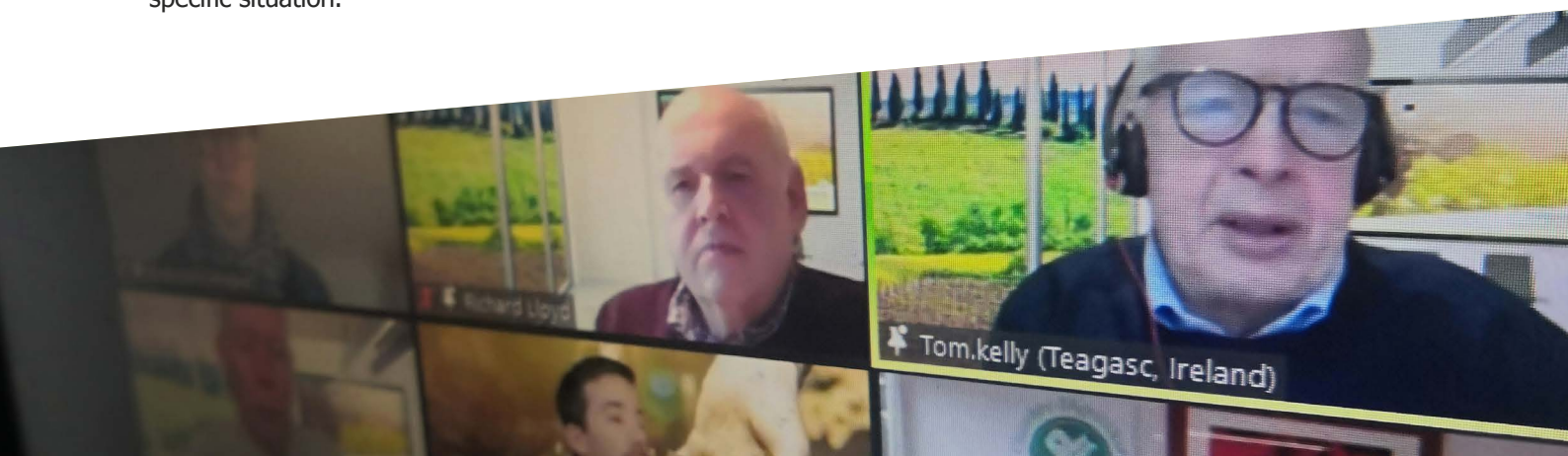
Next, the panellists interacted with participants on the question of how to make these **benefits more visible for farmers**. The experience in 4D4F suggested that the focus should be on how to make better use of the data and how to make earlier and better decisions. Farmers often do not have time to analyse the data. Here, **cloud-based systems** were mentioned as a possible solution since these allow advisors to look at the data and then propose solutions to the farmer on how to improve farm management. The role of trusted advisors is indeed crucial. The FAIRSHARE project learned that advisors are becoming more aware that digital tools can improve their results. The big challenge is that a lot of digital information is held by the farmer and is not readily available to the advisors. Thus far, a lot of data has been successfully collected, but **using that data and using it to its optimum** has been **far less successful**. Advisors need to be able to bring the reports to the farmers directly from the data system, instead of asking the farmer for reports and information over the phone. Furthermore, advisors need training on how to interpret the data and how to share data in the different systems.

The panel discussion was closed by highlighting the **unique cross-border collaboration between Finnish and Estonian Operational Group projects** in. The Finnish OG SMARTFEED project developed a fruitful collaboration with two Estonian Operational Group projects working in the dairy sector. The collaboration has included virtual meetings and a field trip which contributed to building mutual trust between all OGs involved. Similarities and differences were identified together with the benchmarking of different countries. It was mentioned that the cooperation will be continued in new Operational Groups and in an ERANET action.

6. Break-out session: 'Opportunities and challenges regarding farm data use'

The participants worked in 8 break-out groups to discuss opportunities and challenges regarding farm data use. The interactive discussions were facilitated by some guiding questions. A summary of the outcomes per question is presented below, followed by the main messages of the session.

Question 1: What is the level of awareness among farmers regarding the possibilities and benefits of using farm data for the benefit of their own farm?

During the discussions, it was argued that farmers are increasingly using precision farming technologies, but that they are insufficiently aware of the potential of the data they generate. The level of awareness differs strongly between regions and between generations, and it also depends on the size of the farms and the sector. Farmers that are aware of the possibilities, do not always know how to use and/or give value to the data. **It was said that there is too much data, which is often too complex and too difficult to handle. It was agreed that there is an urgent need to simplify, visualise and focus on challenges of direct concern to the farmers and to think of more incentives to make farmers use their data**. Some farmers that want to start monetising data have no clear view on what data can be sold or what would be a suitable business model, and they do not have the time or skills to work on this.
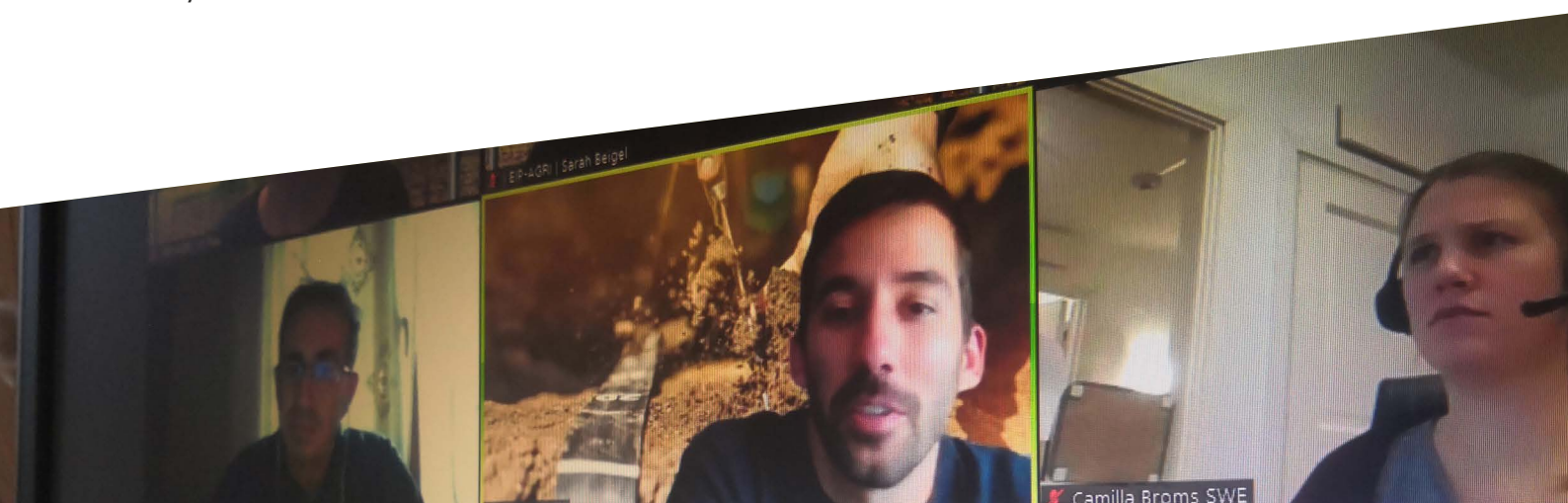
Question 2: Data driven applications must show tangible results and a clear return on investment. Is there clear information available about the costs and benefits?

There was a consensus that there is not enough clear cost-benefit information available. In addition, the costs are usually clearer than the benefits. In many cases, the benefits are less tangible or they appear over time and are only visible in the longer term.

Furthermore, participants argued that it is time to focus less on further lowering the cost and to focus more on creating added value from the data. A lot of data is collected, but farmers are not yet able to turn it into actionable data and to make use of it. How to give value to the data beyond the monetary value needs to be explored. **Reducing the heavy labour time and the administrative burden are important and tangible benefits that can be used to convince farmers**. Overall, there is a need for clearer and more complete information containing all costs, like for example the maintenance cost, which would allow the farmer to make comparisons more easily. Advisory services can help making the benefits clearer and better communicated at farm level in an understandable and tailored way so that farmers can manage data properly. Making cost-benefit information available is one of the biggest challenges.

Question 3: Data interpretation systems and services are needed to turn data into information and subsequently into action. How accessible and useful are such systems and services for farmers and advisors today? Are advisors providing this type of service and what is still needed?

Participants mentioned that often it is better to train the advisor who can then support the farmers. Great improvements have been made, but advisors still need continuous training in the newest technologies to keep up to date with the developments. At the moment, for the latest developments, farmers can only rely on the training provided by companies. Advisors know the farm reality and can help farmers to understand the complex technology by explaining the "black box" to farmers and offer independent objective advice. A question was also raised about whether in the long-term digital tools and dashboards (a visual display of all - or most - relevant farm data) could replace advisory services. However, most participants agreed that farm management decisions should be taken by humans. In addition, **farmers can act as advisors in a peer-to-peer learning system**, which has shown its effectiveness in many projects, lighthouse farms can be very useful in this regard. Policy makers can work on policy and regulations to create new digital business models for farmers and can help to develop incentives and rewarding systems for good use of farm data. In the end, farmers need simple and smart solutions: data that is easy to integrate in their tools and farm management systems and oriented towards compliance with regulation, such as the provision of necessary reports.
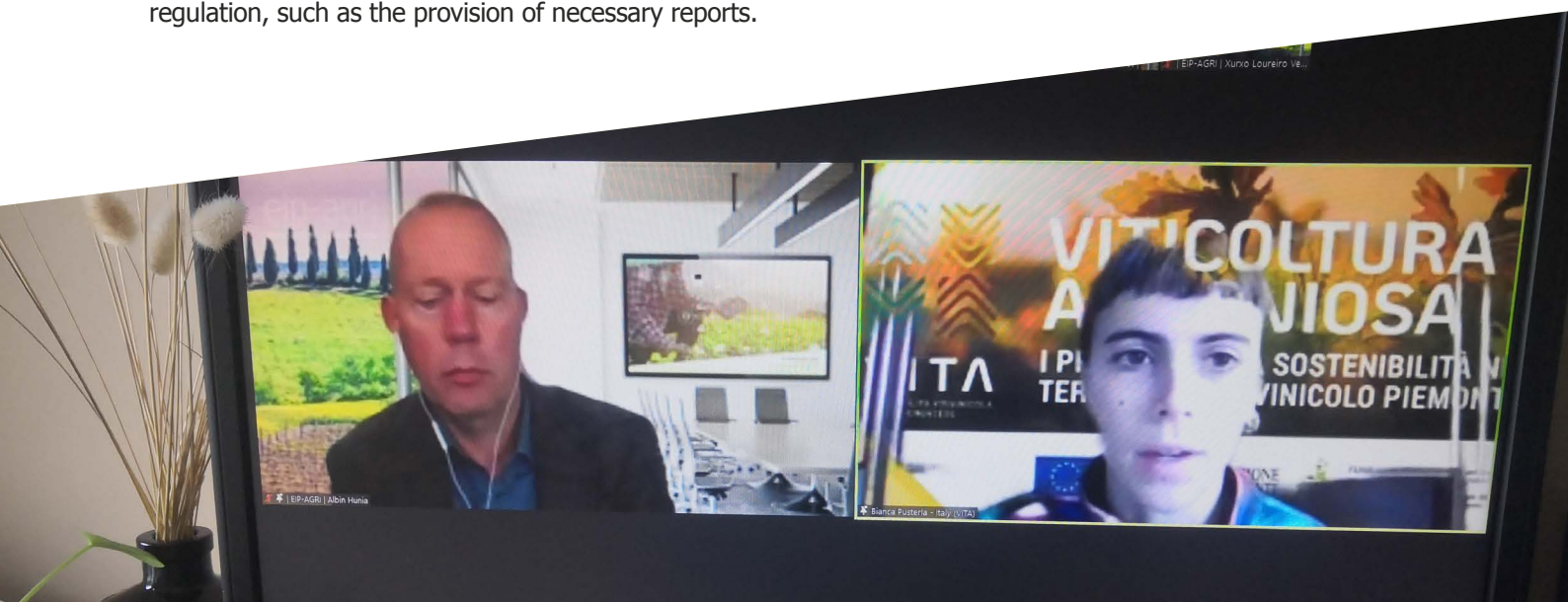
Question 4: What other barriers are farmers facing? What challenges are farmers facing for the uptake and deployment of data- based solutions and services

A number of barriers were mentioned by the participants. Rural areas frequently lack the broadband connectivity to use the full benefit of data and digital solutions. The current design of administration systems might be a barrier, because these systems are not yet fully able to exchange information and to work with the newest data and digital technologies. In addition, it is often difficult to find staff with the necessary skills to work with the technologies. There is an overall need for digital skills and for better understanding of the complexity of the existing systems, and more specifically for knowledge on data ownership, data control and data protection.

The **readiness and the quality of the data clearly need to be improved and large harmonised EU-wide data sets are necessary**. At the same time, there is a great need for more interdisciplinary collaboration. IT experts need to collaborate with experts from other disciplines. More agronomists and other domain experts need to be involved. A final barrier that was mentioned is that **many farmers lack the necessary means to make financial investments**.

Question 5: Which other data is useful for farmers to make the switch to data-based farm management?

Weather data, earth observation data, environmental data and market data were mentioned as other useful data for farmers. It was suggested that farmers could sell farm data to other business actors in the food chain. As the data can be further used in different steps of the supply chain, multiple monetisation should be possible. Data can create more transparency, support sustainability and reduce health claims (e.g. via early disease/pest detection). Data could be also used for marketing and for automatic validation by authorities. Intermediaries could support farmers in the data exchanges. Other actors that can make use of farm data were mentioned: (1) retail and agri-food business, (2) governments, administration, local municipalities and policy makers, (3) paying agencies, (4) banks and insurance, (5) other industry like energy and mobility, (6) certification bodies, (7) researchers and (8) consumers.

Main conclusions from the break-out session

- There is too much data, it is too complex and too difficult to handle. There is an urgent need to **simplify, visualise and focus** it on the needs and challenges of direct concern to farmers.
- Data reduces heavy labour time and administrative burden, these are important and tangible benefits that can be used to convince farmers. Well-trained advisory services can make farmers aware of this and explain the cost and benefits in an **understandable**, very specific way and at farm level so that farmers can manage their farms based on the data and take data driven decisions.
- **Farmer to farmer learning** and demonstrations will further train farmers and boost their digital skills. Together with advisory services knowledgeable of the farm reality, this will help farmers to understand the "black box" – the unknown - of data analysis.
- The **readiness of the data** to be integrated and used is too low. To further improve decision-making, interoperable data and digital technologies need to be fed with EU-wide harmonised data sets. It is important to use multidisciplinary approaches for analysis and clear understandable agreements on data ownership based on the EU code of conduct for agricultural data sharing by contractual agreement.
- Finally, many farmers lack the necessary means for making financial **investments**.

7. Project Market

The event also aimed to provide an environment to exchange best practices on farm data collection, use and sharing. To facilitate this objective, a 'Project Market' was set up during the afternoon of the first day. Participants could promote their projects through short videos. The Project Market was divided in three thematic areas:

1. Animal production
2. Arable crops
3. Permanent crops

A total of 26 project videos were presented. Participants had the opportunity to ask questions and share comments with the presenters. The project videos can be found here.
After the event, six additional project videos and posters were added to the webpage.
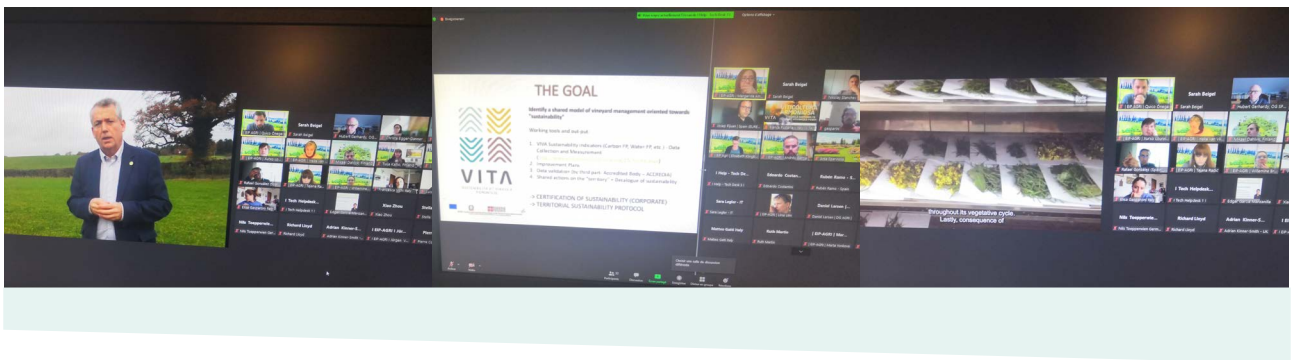
8. Open Space

During the "Open Space", participants were given the opportunity to propose a farm data discussion topic that they considered important and relevant for current and future projects. Both before as at the start of the workshop, participants could propose ideas on a virtual ideas board and commit to hosting a small discussion. The different proposals were grouped into 8 different topics. The rest of the participants could then choose a topic and join the discussion group. The 8 topics and the summary of the group discussions are described below.

Topic 1: Farmer training and empowerment

Participants in this group exchanged thoughts on farmer training. In a context of ever-changing and improving technology, this group questioned how both farmers and advisors could keep up to date. The group agreed that it is important to focus on **young farmers**.

Other points discussed were:
- Farmers **learn best from other farmers** in a familiar environment, for instance by visiting other farms or demonstrations. Advisors can facilitate this peer-to-peer learning.
- In a broader context, farmers are influenced by society and family. There is a need to integrate technology and the use of data in the **school curricula** from an early age, across all subjects. By learning digital skills at school, students bring the skills to the farm.
- **There is not only a digital divide between farmers but also between advisors**. Advisors have to avoid farmers feeling left behind in the extremely fast progression of adoption of digital technologies. The Covid 19 crisis has shown that farmers can make a leap forward when necessary.

Topic 2: Making data relevant and valued by farmers

This group talked about the fact that many farmers are hesitant to share data, especially related to soil, because they a**re worried about losing control of their data**. Two barriers were put forward: (1) data sharing is perceived negatively when used for regulation, (2) data is gathered by companies without clear consent from farmers, without sharing it with farmers and without benefit for farmers. The discussion focused on how to turn around the negative stigma and show how data sharing can be used to empower farmers. An inspiring example was presented about a community fund which had been set up after some community flooding to measure parameters on soil compaction and water management. In order to collect the data, farmers were asked for their consent and they gave their full commitment and trust to share data as it was being funded by the community. In this way, the process was totally transparent and everybody benefited.

The main highlights of the discussion were:
- **Transparency** on what data is being collected, why it is being collected and what is the benefit for the farmer is of key importance for delivering good results.
- The **use of farm data custodians** to ensure that access to the data is authorised and controlled, would be very welcome.
- The results of the data analysis need to be brought to farmers in an **understandable** way and by people who can answer any specific questions from farmers on how this new information allows them to make better decisions on their farm.

Topic 3: Data analysis

The discussion in this group focused on the fact that there is a huge amount of data available for farmers. However, many farmers do not know how to analyse it. It is also difficult to know what data is needed for which goals, or how to integrate data into research.

It was also mentioned that in areas with **many small farmers, these farmers have to be convinced that bringing their data together creates a significant asset for all of them**.

The group also presented the following recommendations:

- Make **the purpose** of the data collection and analysis **clear** to the farmer.
- Start with **a real farming problem** and use data to solve the problem. This will make the benefit very clear for the farmer.
- **Explain the value of the data** and of data sharing especially to small farmers. Advisory services can play a role here.

Topic 4: Business models

Farmers generate a lot of data. This group geared the discussion around the following questions: How can farmers offer their data to other businesses that develop digital equipment and services? How can they monetise the data? What needs to be considered in order to successfully integrate farm data into business models with service providers and technology providers?

To develop new data driven business models, farmers and researchers need **sufficient access to data**. The group highlighted that this is not currently the case. Farmers could act as producers of a 'new product': data. The data can be used to increase the value of products for stakeholders in the supply chain, or to develop new products, e.g. merged data sets of livestock health status and production efficiency could be useful for the pharmaceutical industry.

Some conclusions of the discussion were:

- Most farmers do not claim **ownership** of the data.
- Farmers could work together in farm data cooperatives. Combining health, management and technical data is only possible at farm level. In this sense, farmers have the **power to create valuable information for stakeholders**.
- Farmers can merge **different data sources** to create new data products of interest for other companies in the food chain to increase the value of their products or to further develop their products (e.g. feed consumption, antibiotics used, vaccines applied, organic fertilisers application, biogas production, digital equipment performance). Many aspects still need to be explored: who are the interested stakeholders, what data do they want, what technology is to be used, and what governance system would be best suited?

Topic 5: Barriers to adoption of digital technologies by farmers and their reluctance to share their data

This group discussed the following questions: What are the reasons why farmers do not share data today? What are the differences between the several business models? How can farmers be convinced and incentivised to share data? Will carbon farming and other developments help? Or can new policies that reward farmers who work to increase the provision of ecosystem services help?

The main highlights of the discussion were:

- Many farmers, especially small farmers, are still reluctant to share data. They find it difficult **to understand** the terms and conditions linked to the products or services they buy.
- Furthermore, some farmers feel that they have no control on the data, as they do not store it themselves. More user-friendly systems are needed. For instance, DATA AGRI in France uses a label to indicate which companies respect the data rights of farmers. Here, **farmer associations** could help because farmers trust them.
- Lighthouse farms and farmer-to-farmer learning could help to remove barriers to data sharing. Practical incentives such as agro-environmental or carbon farming interventions, could work as an external motivation.

Topic 6: Data readiness for decision-making and data integration

The starting point of the discussion was the need to clearly explain the reason for collecting farm data and to identify which benefits the farmer can get from the digital service developed from the data. The focus should be on solving the needs and challenges of real farmers.

This discussion group also pointed out that to grasp the full potential of the data, interdisciplinary teams of data scientists and other actors with an agricultural background should be involved in the data analysis.

The main results of the discussion were:

- European-wide **high quality and harmonised data** sets are needed.
- Data-based solutions need a **holistic approach**, instead of looking at them from a one-dimensional perspective.
- The concept of a **federated fair data space** for safe and transparent data exchange between businesses and public could be the way towards more integrated portfolios of data sets.
- A proposal was made to look into the possibilities of Distributed Ledger Technology (DLT) to design improved and trusted data exchange platforms. DLT uses multiple independent computers to record, share and synchronise transactions in their respective electronic ledgers (instead of keeping data centralised as in a traditional ledger).
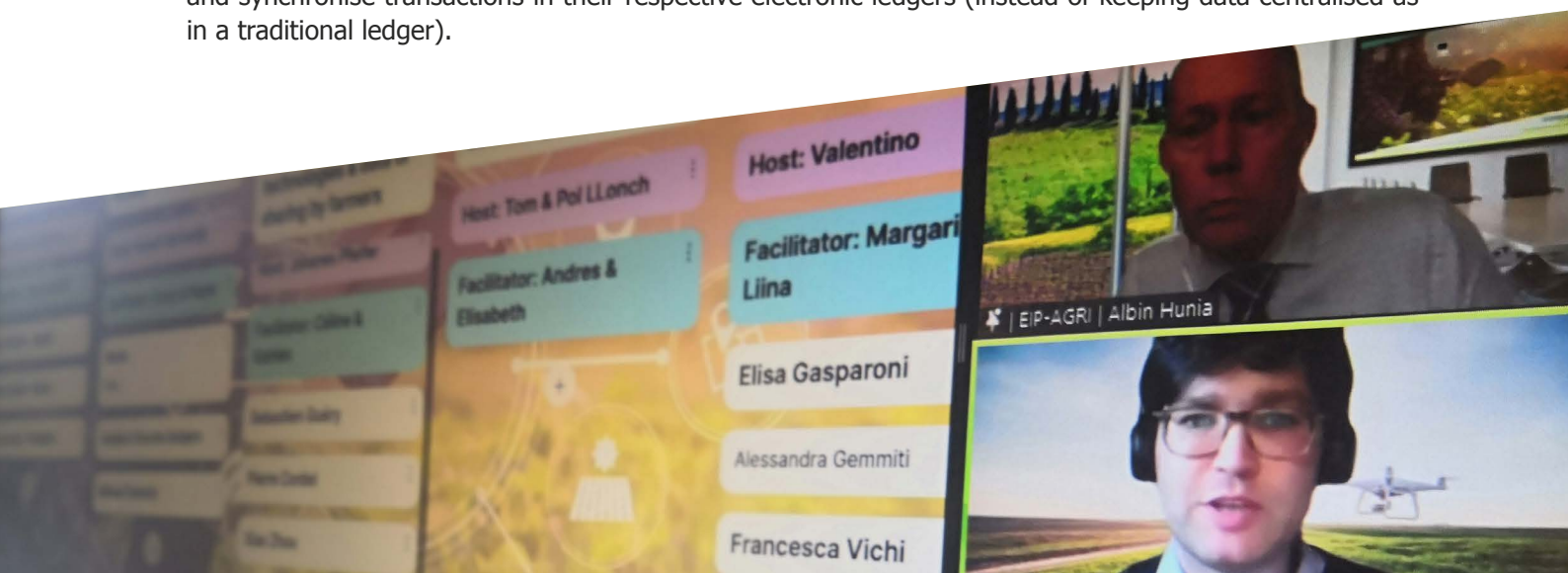
Topic 7: Involving farmers in the innovation process

Despite the availability of technology and precision farming techniques, many farmers are reluctant to adopt them. It was argued that farmers, as central actors, should be more involved in the innovation process, and should be able to align the process to their needs.

The main highlights of the discussion were:

• The benefits of new technologies need to be **demonstrated** and their uptake should be accelerated through farmer-to-farmer learning. Unfortunately, these benefits are not always very tangible, sometimes they are long-term and not easy to demonstrate. For instance, outcomes such as better product quality or increased crop diversity are often not obvious right away.
• **New needs of farmers related to sustainability or certification for example, need to be understood and addressed**. This can be done by discussing with farmers in groups, taking into account farmers' perspectives and explaining that they are working together to achieve a common goal.
• Education on data-based farm knowledge and management are essential to involve more farmers in the innovation process.

Topic 8: How to involve small and medium sized farmers in data economies? What are the differences between large and small/ medium farm data gathering? Including energy consumption for data gathering

Small and medium sized farmers are fully **focused on doing their tasks in order to achieve good production**, even more so than the larger farmers. Many do not have the time to look at the data.

The main highlights were:

• To involve small and medium sized farmers, there is a need for **cooperative approaches** for access to advisory services, to data sharing, to training and to investments in new machineries and tools.
• High-tech precision farming may not always be needed for small and medium sized farmers. **Analysing and understanding their farm data at a basic level** might already be a significant step forward, for instance applying management decisions at field level instead of within field management zones. There is not always a need for new machinery, improving existing machinery can already be a step forward for small and medium sized farmers.
• It is extra challenging for small and medium sized farmers to overcome different legal frameworks and language barriers. **Interoperable solutions** to address these challenges are necessary. Agricultural Digital Innovation Hubs could provide support through knowledge, training and testing, thus supporting better investment decisions.

9. Break-out session: 'How can data solutions support farmers to enhance their farm performance?'

In a second break-out session, participants discussed how data-based solutions can support farmers to enhance their farm performance. The interactive discussions were facilitated by some guiding questions. A summary of the outcomes per question is presented below.

Question 1: What would be a useful data-related solution for farmers?

Solutions are useful for farmers when they are based on **understandable, well-presented and easily accessible data**. Ideally, there should be one single tool that integrates all systems on the farm. For the moment that is not the case. In addition, a data-related solution is useful for the farmer if it is easy to use and, most importantly, if it responds to actual farmers' needs. The ease of use also implies an easy identification of farmers, preferably with one ID for all different businesses and interactions, to reduce the administrative burden. Useful solutions should present several management options to farmers and allow them to compare and choose a customised solution for data driven farming. They should allow cooperation between farmers and should work at different scales. Advisors should know these different solutions and introduce them to farmers, including through demonstrations or pilot farms.

Question 2: Can data cooperatives bring more effective solutions? How?

There was a mixed answer to this question. Some participants had a strong belief **in data cooperatives**. These could be linked to existing farmer organisations, or they could be set up as new cooperatives. However, since developing totally new initiatives takes time, it was argued that building on existing ones, or working together with and among existing cooperatives might be a better model. Nevertheless, **it is challenging to convince existing cooperatives**. They need to understand the added value for them and they should be provided with sustainable business models. Experiences from France, Belgium (Flanders) and the Netherlands show that cooperatives may start locally or at regional level to build trust and then develop further, step by step, taking into account the different levels of development in business, technology and governance. In addition, farmers need support to better understand the benefits of sharing their data in a cooperative.
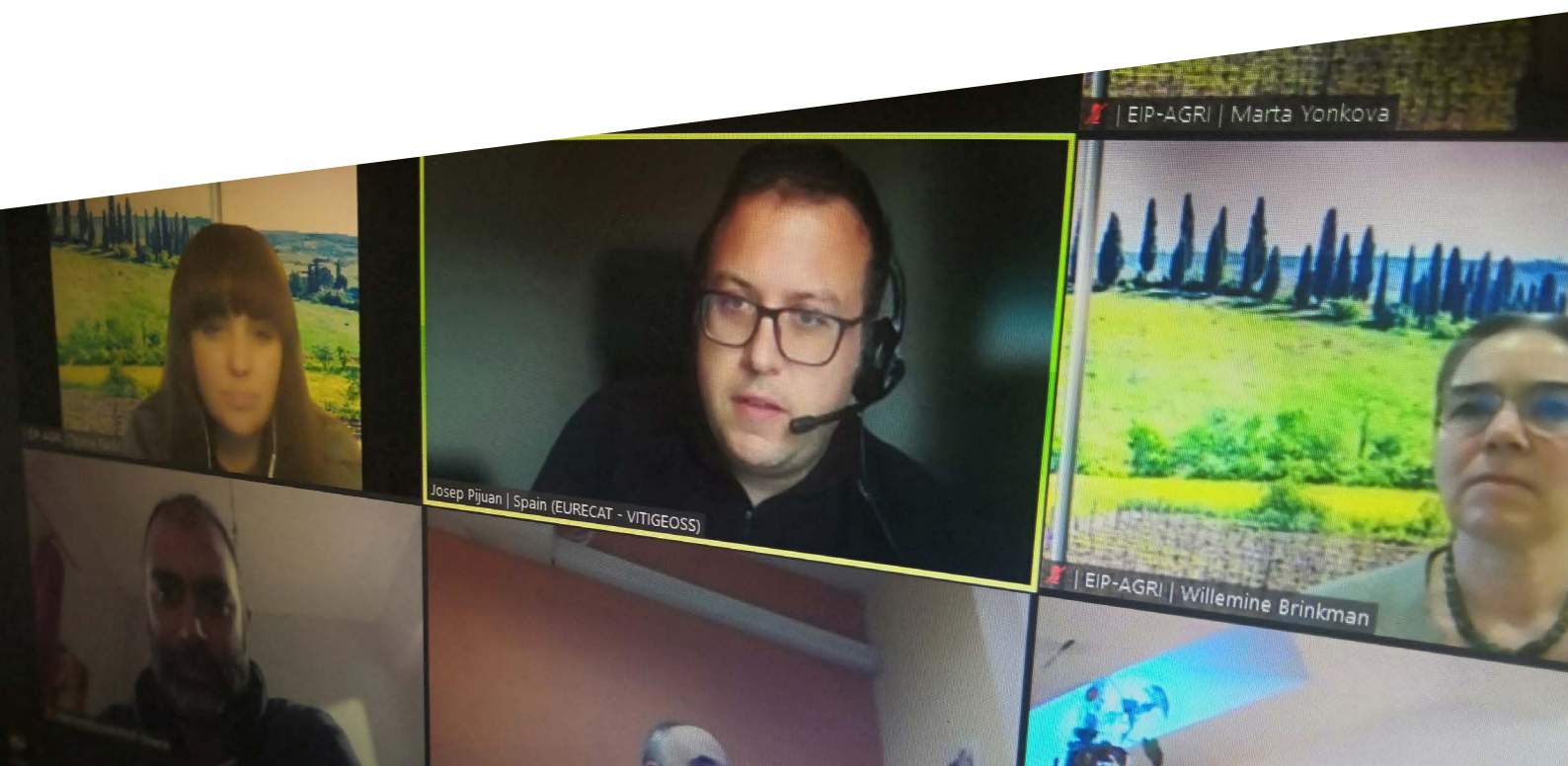
Cooperatives could work **at inter-regional level** so that farmers can share and use data from different regions. This can help to bring different types of data together from different sources (environmental data, weather data, production data, …), add value and promote benchmarking.

Taking control of and managing the data is very difficult and expensive for one single farmer. Cooperatives can invest on behalf of many farmers and thus work in a **cost-effective way**. They can also help introduce and test (data) solutions, indicate what solutions are effective and make use of farmer-to-farmer learning effects. They can also centralise the requirements of processors and retailers and push standardisation together with the public authorities.

Participants made the difference between real data cooperatives focused on data, data sharing and data valorisation, and cooperatives focused on shared use of precision farming technologies and applications.

Other participants stated that not all cooperatives are trusted by farmers. Instead of data cooperatives, they suggested to work with **professional companies that have the right competences**. Contractors can play a role here. As they are up to date with the latest trends, they can introduce technology faster and demonstrate it to farmers. It was also mentioned that not all farmers feel the need to share data with other farmers. Some farmers prefer to keep their farm data private.

Overall, there is an agreement that independent organisations are needed as well as good governance models to gradually build a data space. Good examples were given from Ireland and Finland. In Ireland, soil data was gathered as part of a government catchment project. In Finland, cattle and pig cooperatives ensured that farmers remained the owners of databases. They worked with dairy companies and slaughterhouses, which could ask for the data they wanted to have. Interfaces with farm management software were established.

Cooperatives could help with environmental monitoring and to show the general public in a more transparent way how farmers are implementing technologies for improving their environmental performance.
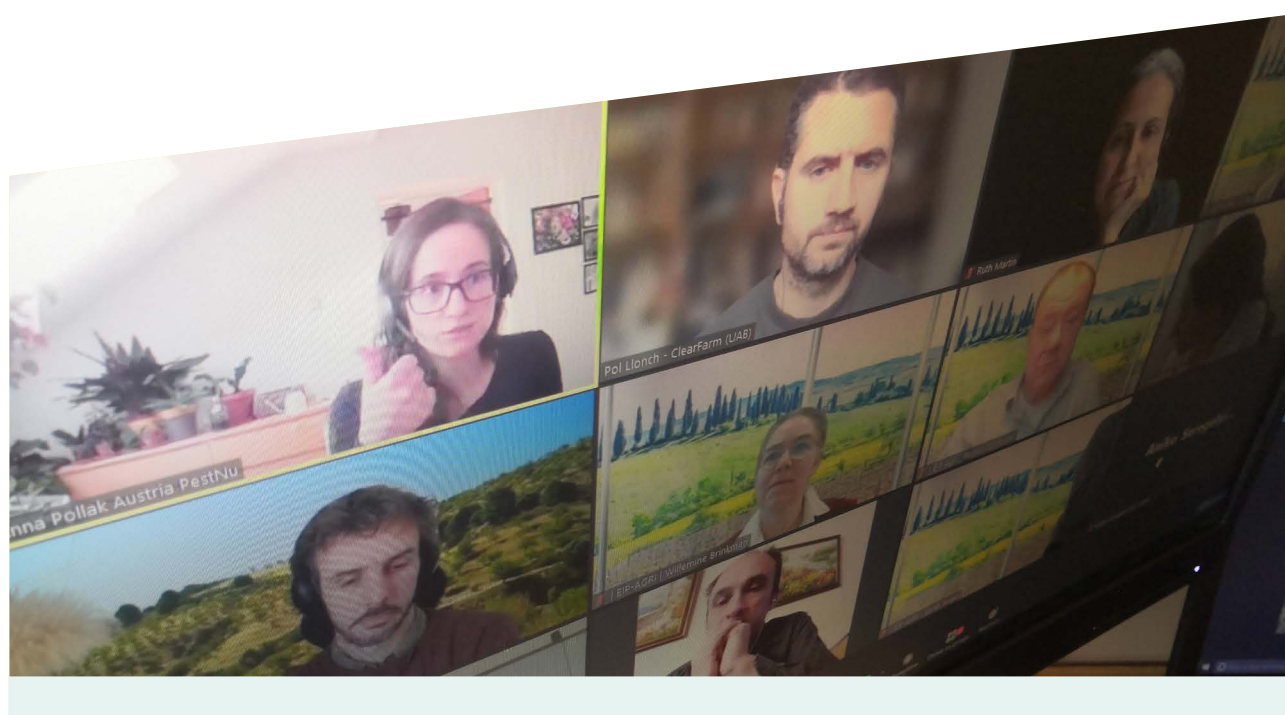
Question 3: Can sustainable business models based on data be built?

There was a discussion on the question whether the **data can be monetised as a product itself**, whether data should deliver value **via the services** built using it, or whether both are possible. The delivered service will bring more value if it is fed by more and better data. **Just having data does not guarantee an extra income for farmers**. The data needs to be brought together and integrated. Some participants stated that currently not enough qualitative data is available to offer data as a product or to build efficient services.

Furthermore, at present, the infrastructure for sharing data is insufficient and more governmental support is needed. An option would be for **governmental actors** to provide the infrastructure, as is done for other utilities. **Machinery companies** are currently one of the few actors that can do the necessary investments to build data platforms and gather the critical mass of data to develop services on it. When a **data cooperative** wants to set up a data sharing initiative, high start-up investments are needed for infrastructure and software. In addition, the initiative needs to be populated with data before it can start sharing the data. Data providers and data users will have to pay for the use of the platform before they can start exchanging data and discuss about the value.

To build a sustainable business model, farmers need to be able to get **financial compensation**, which is not the case as long as the focus is only on environmental measures. In Italy, **product labeling** motivates companies to pay for the data they need for the labeling. This could be the basis of a sustainable business model. Another example of data for sustainable business models is weather station data that allows advice on when to fertilise, and therefore creates better nutrient efficiency and reduces environmental impact. Animal genetics data is another example. When exploring new business models, it is necessary to look **beyond the farm gate** to the entire chain and even to other domains, like energy or transport. It was mentioned that an initiative bringing together all existing data in its different formats, from several actors (public and private), in diverse systems and that would make it easily accessible while respecting ownership of data, would be welcomed.

An inspiring example from Poland was presented about a business model for the setting-up of automated insects traps. An accurate network of equipment with a good coverage in the orchard areas was key. Big producers would pay for the devices and acquire high level protection. At the same time, the information from the infestation map was sold to smaller actors who were unable to invest in the devices. This way, these smaller actors could also get protection based on the information received from other farmers.
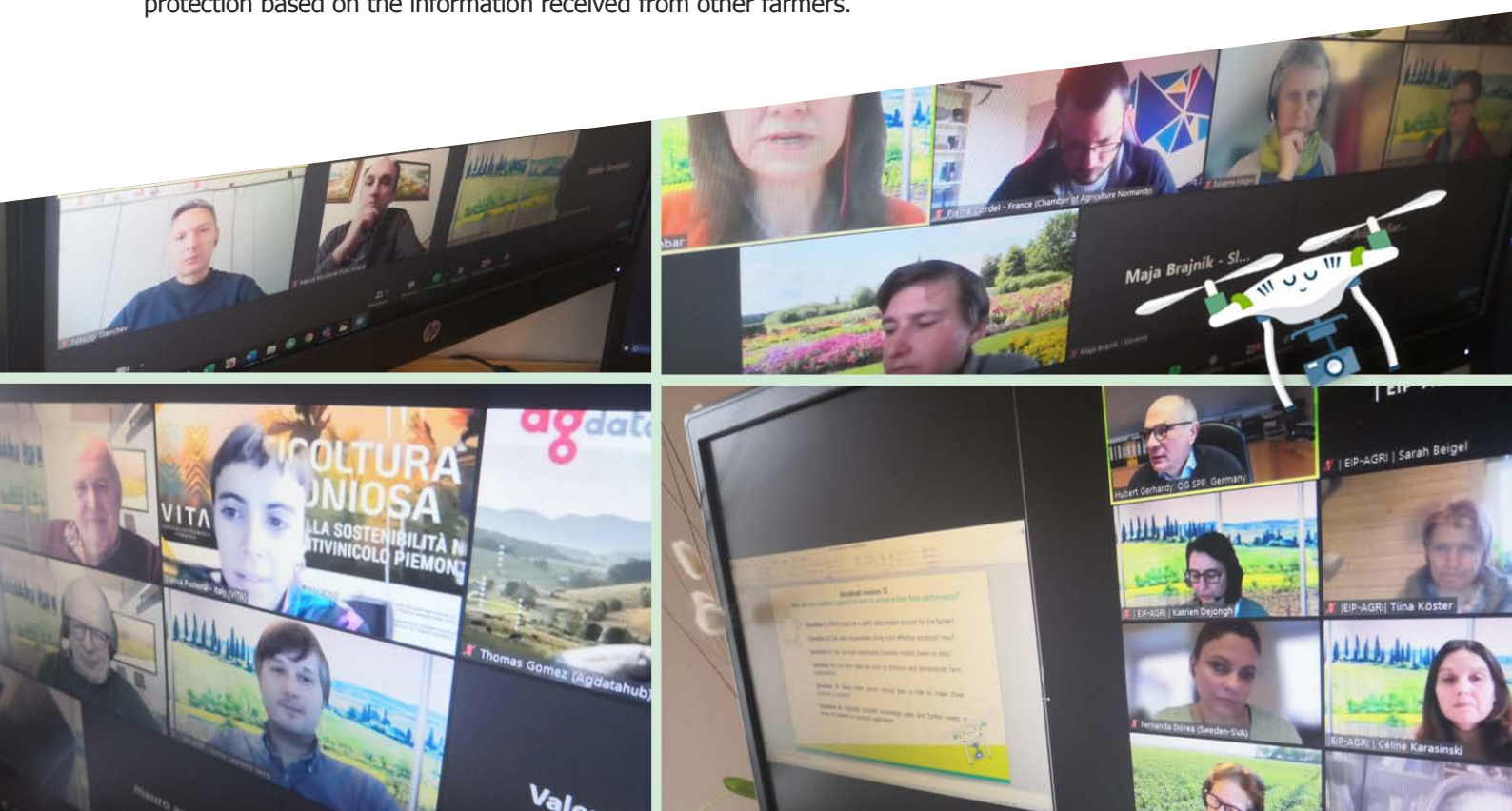
Question 4: Can farm data be used to enhance and demonstrate farm sustainability?

Data can help farmers to analyse the situation on their farms and then make good decisions. Benchmarking is also a possibility with farm data and this can help farmers to improve sustainability. Farmers can best start with simple applications such as a basic accountancy tool.

Social, economic and environmental sustainability is important. Farmers do not count their own working hours. Using tools like farm management information systems (FMIS) to register working **time and costs**, gives them better insights to get **fair prices** for their work done. Another example is the use of data to evaluate whether the farm machinery is being used efficiently. Soil data plays an important role in enhancing environmental sustainability, but of course, the main challenge is to translate this data into useful information. Some participants stated that enhancing environmental sustainability is more feasible than the other components of sustainability.

To enhance and demonstrate farm sustainability, farmers should work more closely together with **researchers**. An example that was brought forward is the application of plant protection products: when comparing the results between different farms, it becomes possible to design the optimal application method. The Farm Sustainability Tool (FaST) is a good example because it supports farmers and farm advisors in their activities related to sustainability. A concrete example from Poland was presented: a farm producing carrots achieved a reduction of 10-12% on water use using simple water sensors.

More and more consumers value better quality. Suppliers are obliged to demonstrate that agricultural commodities are produced in a sustainable and traceable way. Data can help farmers to show the sustainability of their production systems. Using data to be transparent about the production process could help them to gain value and have a good marketing positioning, e.g. data on animal health in livestock production can be used to inform farmers but also consumers. Consumers will better understand the environmental impact of the product and its price. Transparency brings value and delivers a license to produce. New technologies like Distributed Ledger Technology (DLT) that support traceability can help here.

Question 5: What other actors should play a role to make these solutions a success?

There was a broad consensus that i to make progress in unlocking the potential of farm data, **all actors in the chain (from farm to fork) need to play a role**. To create value, the data has to be used in the different steps of the chain. This value should then return to the farmers. First, in the farmer community, **pioneer farmers and lighthouse farms** are needed to lead by example and convince other farmers. Farmer cooperatives engaging in data sharing can also help to build trust. Then, input suppliers, transport companies, processors, retailers, they all need to step into the 'data exchange system' and help to create value for all actors. Machine manufacturers were explicitly mentioned as they are able to collect a lot of data via their machinery in the field and they also have a relationship of trust with the farmers. **Governmental actors** should share the data too, respecting the rights of the data owners. **Public decision makers** can also help via trade regulations and legal initiatives. **Consumers** should be aware that they have to pay more for products that come with extra information based on farmers' data. At the same time, **consumer data should flow back to the farmers**, as important feedback information. Actors in other domains, such as energy or mobility, can integrate their data with farm data and create value. **Education and (legal) advisory services play an important role too**. Legal advice might also be necessary to better support farmers when signing contracts. **Agricultural Digital Innovation** Hubs are important initiatives that can deliver skills, training, testing facilities and help in searching for financial support. There is also a role for **funding bodies to fund projects** that focus on integrating data and on putting the data into action rather than on creating more data. Other private funders can have a role too, if they can be attracted by sustainable business models. .
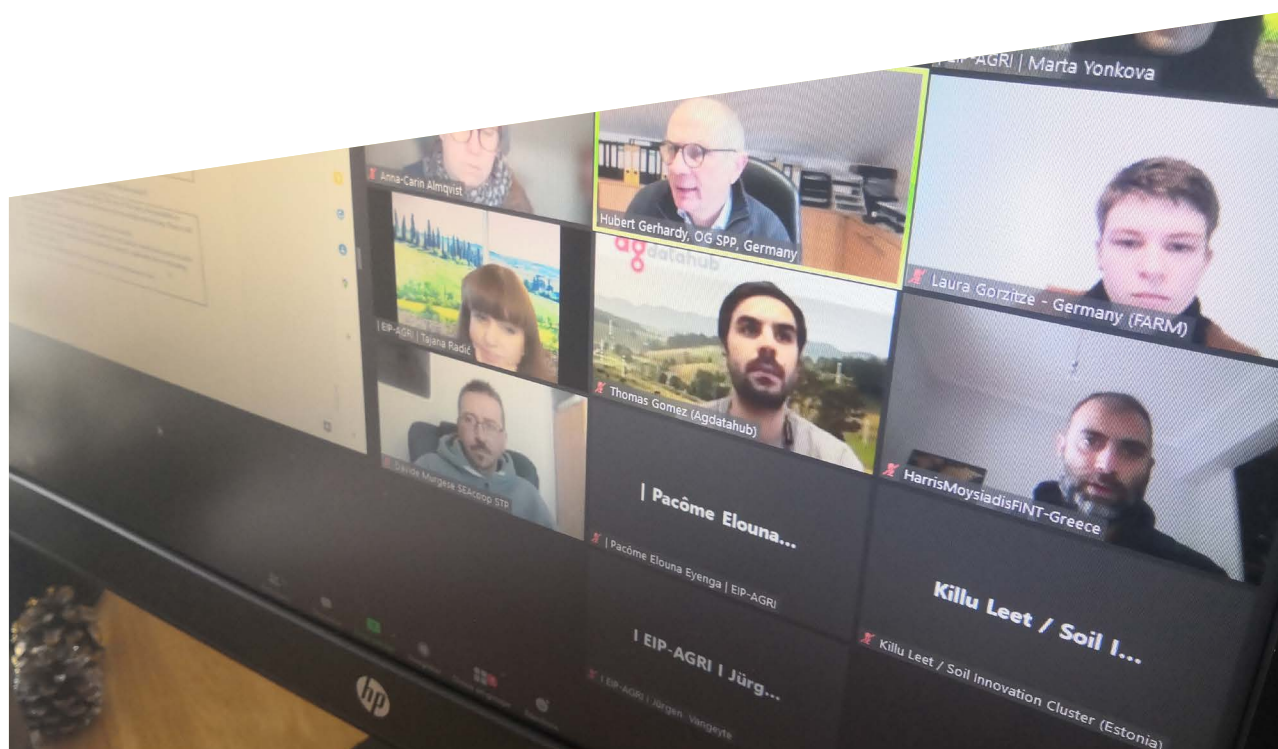
10. Conclusions and recommendations

In this two-day workshop, farmers, advisors, farm technology developers, the research community and innovation agents, discussed how innovation and knowledge exchange can help farmers to unlock the full potential of the data on their farms. The challenges for farmers applying **smart data management** to work more precisely, efficiently, and sustainably were analysed from all perspectives and discussed in depth.

Inspiring videos showed **good examples** of how farm data can be beneficial for farm performance. The panel discussion made clear that benefits such as a **lower administrative burden** can convince farmers to start sharing data, but also that **quantifying the benefits** remains an important challenge. Moreover, it was highlighted that individual farmers do not have the time to market the farm data by themselves.

Throughout the workshop, participants were **actively engaged**. In the 'Project Market' they promoted their projects and good practices through short videos and in the 'Open Space' they initiated their own discussion topics and invited other interested participants to join and exchange ideas.

Based on the various exchanges of ideas and discussions, which also included break-out sessions, the participants identified the following knowledge gaps and further needs in terms of research or practical application:

- Integrated data for better and more complex decision-making
- Simplified, visualised and demonstrated data solutions for better use by farmers
- Two-way data flows to improve the value for all
- Integration of farmers' knowledge for improved digital services
- Exploring the cooperative model for trusted data sharing

Each of these are described in more detail below.

Possible knowledge gaps and further needs in terms of research or practical application

Integrated data for better and more complex decision-making

There is an urgent need to integrate data from different sources and to scale up to create harmonised, easily accessible and qualitative data sets. These sets are needed to take the step to interoperable digital solutions that support complex data driven decision-making. This is linked to the concept of a data space and the proposed partnership Agriculture of Data.

Simplified, visualised and demonstrated data solutions for better use by farmers

A better understanding by farmers of the data and its value is needed. To address this need, further exploration is required on how data can be simplified, visualised, more easily accessible, better explained and applicable at farm level. To achieve a better involvement of farmers, it is recommended to start from a real farming problem and to use data to solve this problem. This means that more domain experts and IT experts should come together, in order to ensure they are 'speaking the same language'. Specialised advisors could become data interpreters and could demonstrate the value and the benefits of data (short, medium and long term benefits). Besides the benefits, the costs should be made clear and should be demonstrated. The transaction costs, ie. the time farmers and advisors invest in finding optimal solutions, should not be underestimated. Data intermediaries and platforms need a thorough understanding of the needs of farmers and the farm ecosystem.

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Two-way data flows to improve the value for all

Data should not stay on the farm. It needs to flow up the supply chain to create value. Farm data can help suppliers to show the sustainability of their production systems in a traceable way. The consumer values this information and appreciates transparency. However, it is also of upmost importance to bring data from outside the farm back to the farm. Data from slaughterhouses, processors, suppliers, retail and even from the consumer, needs to flow back to the farmer. Even further, citizens could also deliver valuable data to farmers, e.g. using sensors to monitor water soil moisture in their back gardens.

## Integration of farmers' knowledge for improved digital services

To improve the algorithms for decision-making and to respond to new and upcoming needs of farmers, it is crucial to take into account their practical knowledge and experience. Data and digital technologies should be used to do on-farm experimentation, to involve farmers in improving the algorithms and to develop solutions on real farms, instead of via experimental farms. To involve farmers in this way, education plays a crucial role. There is still a knowledge and capacity gap regarding secondary schools that needs to be addressed. Study programmes need to be updated and teachers need to be engaged to focus more on digital knowledge. By learning digital skills at school, students will be able to support digitalisation on the farm.

Exploring the cooperative model for trusted data sharing

Creating qualitative combined farm data sets should start at the level of individual farmers. Therefore, cooperative models and related business models for sharing and valorising data need to be further explored. The needs of small and medium sized farmers should also be considered. Cooperation can unlock the power that farmers have to generate valuable information for stakeholders in the value chain based on large integrated farm data sets. Farm data cooperatives, either built on existing cooperatives or newly created, have many advantages such as cost effectiveness and easier access to many data providers and data users. Moreover, they can take into account the regional perspective and associated needs. They can also be the basis of more cooperation with researchers and provide extra support for education, advice, testing and investments. Cooperative data sharing intermediaries can take care of tasks related to data exchange and valorisation that farmers may not be able to attend to due to time constraints. Most importantly, data cooperatives can help to build trust. They can act as data custodians and ensure that farmers stay in control of their data, as agreed in the Code of Conduct on Agricultural Data Sharing by contractual agreement and attend to data security issues.

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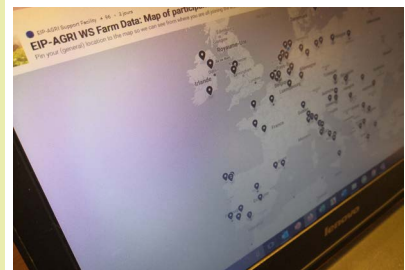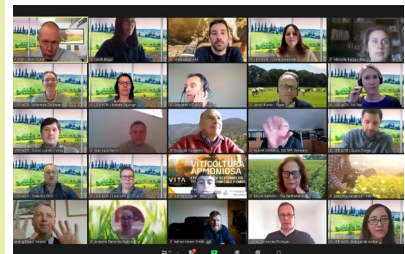European Commission
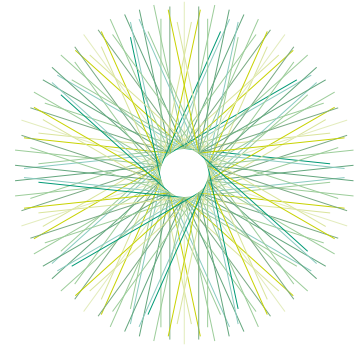
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