INTERNET OF FOOD & FARM

TOWARD BROADER SHARING OF FARM DATA

RECOMMENDATIONS FROM THE USE CASE COORDINATORS

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PROJECT SUMMARY

The internet of things (IoT) has a revolutionary potential. A smart web of sensors, actuators, cameras, robots, drones and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry.

The goal is ambitious: to make precision farming a reality and to take a vital step towards a more sustainable food value chain. With the help of IoT technologies higher yields and better-quality produce are within reach. Pesticide and fertilizer use will drop and overall efficiency is optimized. IoT technologies also enable better traceability of food, leading to increased food safety.

IoF2020 involves 33 use-cases organised around five trials (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe, with the first results that were realised in the first quarter of 2018.

IoF2020 uses a lean multi-actor approach focusing on user acceptability, stakeholder engagement and the development of sustainable business models. IoF2020 aims to increase the economic viability and market share of developed technologies, while bringing end-users' and farmers' adoption of these technological solutions to the next stage. The aim of IoF2020 is to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. Therefore, key stakeholders along the food value chain are involved in IoF2020, together with technology service providers, software companies and academic research institutions.

Led by the Wageningen University and Research (WUR), the 100+ members consortium includes partners from agriculture and ICT sectors, and uses open source technology provided by other initiatives (e.g. FIWARE). IoF2020 is part of Horizon2020 Industrial Leadership and is supported by the European Commission with a budget of €30 million.

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EXECUTIVE SUMMARY

Stakeholders involved in digital farming networks are not always eager to share their data. Even though different stakeholders have begun shaping guidelines to improve farm data management practices and foster trust in farm data sharing, distrust in sharing farm data persists. During the project Internet of Food and Farm 2020 (IoF2020), use case coordinators gathered a lot of experience with data sharing. In this study we wanted to acquire overview over these experiences. We tried to answer to the following questions:

1. What are current data sharing practices in use cases in IoF2020?
2. What are perceived benefits of data sharing?
3. What are perceived barriers regarding data sharing with other, additional actors for the use cases?
4. What strategies to overcome the barriers can farm data platforms offer?

To find an answer to these questions we conducted 33 interviews (one for each use case), mostly with use case coordinators. We asked about current and potential future data sharing practices, added value of data sharing, obstacles experienced when sharing data and their view on possible solutions to the obstacles. 17 interviews were transcribed verbatim and analysed based on a grounded theory method. As our research had reached saturation, we chose to analyze the remaining 16 interviews more generally, looking at whether they offered support to any of the themes we had already identified, and we scored this support. Furthermore, for all 33 interviews current and potential future data sharing practices were noted in a table, specifying the type of actors that were sending or receiving data and characterizing the type of data that was sent.

The answers that we found to our research questions can be summarized as follows.

1. *Current data sharing practices*

While most use cases have a large interest in data sharing, use cases usually only shared data with partners who were already part of their use case but rarely beyond that. There is an exception for farmers who are most often seen as external actors as their contribution was rarely funded within the use cases. Considering that in almost all use cases, farmers were mentioned as important senders and/or receivers of data, there are almost always farmers involved as 'external partners' in data sharing, next to some (few) other external actors. In total, the number of data flows sent by farmers are larger compared to the number of data flows sent by other actors. Other actors frequently involved in exchanging data (sending and receiving) in all use cases are tech providers (companies), commercial cooperatives, producers, processors and research institutes (commercial as well as public). While universities are sometimes involved in use cases, other public institutes, such as policy makers/ministries/municipalities or controlling bodies of the government, are only incidentally participating in the data sharing network. Furthermore, societal organisations like NGO's are rarely involved. Since data are not often shared with policy or societal organisations, realising broader, societal goals or fostering policy development has not been the most

important goal of data sharing in IOF2020, nor did use case coordinators mention it during the interviews as their priority to share data for in the future.

2. *Benefits of data sharing, obstacles and solutions*

When asked about the benefits of data sharing, most use case coordinators primarily reflected on the value of data sharing for farmers and growers. The main benefits are (1) that it enhances knowledge for farmers, which allows to tailor farming activities to the needs of the crop or animal, which improves the quality and quantity of the products; (2) it helps to optimize food production processes, which means that they become more efficient, cheaper and collaboration in the value chain becomes more fluid, and (3) data sharing helps to save time and realize more revenues for farmers.

Obstacles to data sharing that use case leaders brought forward include (a) lack of information/knowledge of farmers and growers about the benefits that data sharing can offer them, (b) unclarity about the financial benefits that it brings (and uncertainty to do investments now, when benefits are expected at a later point in time), (c) lack of technological standardisation and (d) legislation and regulation-issues, which include existing legislation which obstructs data sharing as well as lacking legislation, for example when it comes to settling questions about who is the data owner and what rights belong to data owners.

Although use case leaders have experience in different farming sectors, they bring forward similar benefits and obstacles when it comes to data sharing for farmers and growers.

The solutions that use case leaders mentioned most frequently responded to the obstacles they brought forward, such as (i) informing and educating farmers about the added value of data sharing, (ii) providing incentives to get them to share data, (iii) change and/or add new legislation, (iv) realise technological standardization and (v) foster a socio-cultural transition by offering subsidies for collaborative projects, realise open data-bases (or data libraries), or simply by giving farmers and growers time to learn about the technologies, experiment with them and adapt their farm to include them in their daily production routines.

3. *Discussion of results*

The results cohere with findings from many research articles that have reported similar results in relation to the slow adoption and acceptance of smart farming technologies, which could be seen as an affirmation of the findings. However, it is important to take into account the limitations of this research. For this study we most often interviewed only one participant of the use case, the coordinator, who was often (but not always) a tech developer. Hereby we assumed that this person was able to represent the opinions of the entire use case. But, of course, it is likely that other participants who have other roles in the use case (for example, farmers, food processors etc.) would have another story to tell about the added value of data sharing as well as the obstacles encountered for that and the solutions offered.

Furthermore, our interviewees primarily talked about data sharing in relation to farmers and growers who feel hesitant or reluctant to share data, but they rarely spoke about obstacles encountered with other types of stakeholders. The overview over current data sharing activities, however, reveal that data are

rarely shared beyond the limitations of the use cases. This suggests that other stakeholders, beside farmers and growers, are also not eager to share data. This fits with remarks that respondents made in earlier focus groups on data sharing carried out in WP7, where tech providers remarked that they tended to protect their data as their business case was based on their access to a unique data set (D7.4, Van der Burg 2020b).

This is important to take into account when looking at the solutions that use case leaders bring forward to overcome obstacles for data sharing and which we noted in the recommendations below. While some of these solutions try to foster open data flows, which allow to use data for research, innovation and to foster the market, it is also important to realise that business interests in unique data sets may also limit the openness of data. This needs to be taken into account in further work on the enhancement of data flows in farm data spaces.

4. Recommendations

Based on the results of the interviews with 33 use cases, we come to the following recommendations for actions that various actors can take to foster data sharing.

For governments:

- Make some data sharing mandatory, for example with respect to showing compliance with the law, or for the fostering of public goals, such as food safety or the protection of natural resources and the environment
- Create incentives to share data, for example by offering subsidies or tax-advantages when actors decide to share data
- Assess present regulation which protects data and look for possibilities to (a) change regulation where it imposes unnecessary limitations to data sharing, and (b) create new regulation to clarify the rights of data sharing partners, such as for example data ownership rights which point out who is entitled to decide about and benefit from what data
- Support new projects which foster collaboration between actors in the farm data sharing network, which allows to experiment with the technology, as well as with the collaboration with the data-based social network around it
- Foster standardization of technology by offering subsidies and demanding to make data FAIR
- Foster the development of databases (as 'libraries') which are accessible to all actors and which allow to experiment with data and get to know what can be done with them, or learned from them

For farmers (or farmer cooperatives):

- Educate and communicate clearly about the benefits of data sharing, as well as the risks
- Foster collaboration in projects which allow farmers to become acquainted with digital farming technology and experiment with the technology, as well as with the social collaboration around it
- Think about preconditions that need to be satisfied before sharing farm data, which help the farmer to make sensible decisions about when to share data, for what purposes and with whom

- Act as a true representative of farmers in the negotiation with other stakeholders in the data sharing network, in order to make sure that farmers can harvest benefits of digital farming while protecting them against the harms it may bring them
- Empower farmers by giving them digital education

For tech companies:

- Take responsibility to give something valuable back to the farmer or other actors in exchange for their data.
- Explain to the farmer what they are going to do with the data and why and ask for consent
- Participate in collaborative projects like IoF to become acquainted with and foster data sharing collaborations, and in that way foster a data sharing culture
- Share data for public purposes, such as food safety or the environment
- Make data FAIR
- (And perhaps) Think about preconditions that need to be satisfied to share data with other data sharing partners, without harming one's own business model

For providers of data platforms (such as Joindata and dJustConnect):

- Education and clear communication of the added value as well as the risks of sharing farm data on data platforms:
    - Show on the platform what the actual benefit is for the farmer when the data is shared with for example a company (will they get money, information, what are estimations for the extra profits they can expect?)
    - Provide clear and accessible information about what the data user will do with the data and (possibly also) what profits he/she will harvest from that and give something back to the farmer in exchange for those profits
    - Provide clear information about the risks related to data sharing and how the risks are mitigated
    - Work toward making data FAIR, in order to be able to connect to data from other platforms

1. INTRODUCTION

Europe wants to become a data-driven society. This is the purpose of the European Data Strategy (European Commission 2020). While personal data which contain identifiers to a specific person are protected by the General Data Protection Regulation (GDPR), and there is competition law protecting data that could jeopardize fair competition between companies, the free flow of all other data which are not protected by these laws is being fostered (European Commission 2020).

Data stemming from digital farming technologies are often unprotected by either the GDPR or competition law. Usually farm data do not refer directly to the name or address of a person or to sensitive personal or competitive information. Digital farming technologies collect and process data that are usually not protected; such as, data about chemical components of soil, soil humidity, weather data, emission-data, data about the health and growth of crops or animals, medication data (such as anti-biotics for animals or pesticides for plants) etc. The free flow of these data is fostered in the European Union, as having access to them is thought to empower businesses, (research) organisations and (European, national and local) policy, as they provide better knowledge and enhance innovation activity.

In the past years, however, it has also become abundantly clear that stakeholders involved in digital farming networks, are not always eager to share these farm data. The free flow of farm data is therefore far from reality. Interviews and surveys carried out in different parts of the world, such as Australia, New Zealand, North America and the EU, have focused on farmers and pointed out that farmers are often unwilling to share their data (Jakku et al. 2019; Wiseman et al. 2019; Regan 2019; Fleming et al. 2018; Carolan 2017; Zhang et al. 2017). Farmers often distrust the agribusinesses who ask for their data, as they suspect they will re-use these data to build other businesses and services which will benefit them but not the farmer. Furthermore, farmers suspect agribusinesses may sell their data, use them for profiling or as pre-information, prior to their investments on the stock market.

In response to farmer's distrust of farm data sharing, different stakeholders have begun shaping guidelines to improve farm data management practices and foster trust in farm data sharing. In the US, the American Farm Bureau launched the Privacy and Security Principles for Farm Data in 2014[1]; and in the same year the New Zealand Farm Data Code of Practice[2] was published. In the EU, farmer's representatives from Copa-Cogeca and CEJA (Conseil Européen des Jeunes Agriculteurs) and major agribusinesses presented the EU Code of Conduct for Agricultural Data Sharing by Contractual Agreement in 2018[3]. And in 2020, Australia published the Australian Farm Data Code[4].

These principles, codes of conduct and codes of practice provide a valuable start to the discussion about preconditions for farm data sharing that need to be respected to realise trusted data sharing practices. But these discussions are not completed yet, for distrust in farm data sharing persists. During the project

[1] https://www.fb.org/issues/innovation/data-privacy/privacy-and-security-principles-for-farm-data
[2] http://www.farmdatacode.org.nz/wp-content/uploads/2014/06/farm-data-code-of-practice-final.pdf
[3] https://www.cema-agri.org/index.php?option=com_content&view=article&id=37&catid=19&Itemid=216
[4] https://nff.org.au/programs/australian-farm-data-code/

Internet of Food and Farm 2020 (IoF2020), use cases have gathered a lot of experience with data sharing. While participants in all use cases have been involved in focus groups where they have been asked to think about the future of data sharing in the context of WP7 on ethics (see Van der Burg et al. 2020b), in March 2020 the review committee of IoF2020 asked to contact all use case leaders and collect their opinions about whether and how data sharing can be fostered toward the future. The main questions we seek to answer in this report are therefore:

1. What are current data sharing practices in use cases in IoF2020?
2. What are perceived benefits of data sharing?
3. What are perceived barriers regarding data sharing with other, additional actors for the use cases?
4. What strategies to overcome the barriers can farm data platforms offer?

These questions and their answers will be used for policy recommendations for a variety of actors that are involved in data sharing practices in the agri-food sector, such as governments, tech-companies, researchers and farmers organisations.

2. METHOD

In order to attend to the differences between the use cases, we chose to do qualitative semi-structured interviews, which approaches interviewees with a list of themes but also allows them some freedom to steer the conversation in directions that they see fit (Longhurst 2016).

To shape our interview guide (and avoid overlap with questions that were already asked to use case coordinators) we first looked at the review reports of the use cases, as well as the questionnaire shaped by colleagues who were conducting a similar research in the context of the DATAFAIR project. Based on this comparison, and after collecting feedback from these colleagues as well as all WP leaders of IoF2020, we revised our questions and finalised them. In the interview guide we included questions about current data flows, potential future data flows, obstacles and difficulties encountered during data sharing, as well as on possible ways to overcome those obstacles. The interview guide can be found in Appendix A.

2.1. Data collection and analysis

To recruit respondents, we contacted use case coordinators via email and asked for their cooperation. The interview guide was attached to this email, which gave them the opportunity to already look at the questions beforehand and prepare their answers. Eventually all use case coordinators consented to an interview. We conducted 33 interviews (one interview for each use case) in the period from end of July to the beginning of October 2020. Most interviews were done with use case coordinators, sometimes (together) with other members of the use case project team. After receiving verbal consent, the audio of the interviews was recorded. We analysed the results in two ways to serve our double purpose, which is to (1) describe perspectives of use cases to the added value of data sharing, the obstacles they encountered and the solutions to overcome the obstacles and (2) create an overview over current data flows for all use cases.

2.1.1. Expected added value, obstacles and solutions to the obstacles

To describe the perspectives of use case coordinators on the added value and obstacles to data sharing, and the solutions for the obstacles, we used a qualitative research method. In qualitative research, respondents are usually recruited until saturation is reached. That means that new respondents will be included for interviews up until the point where the interviewers hear no new information anymore, but when they start to hear repetitions of themes that previous interviewees mentioned. Usually at that point, no further respondents are included and the interviewer bases the analysis on just those interviews. In our case, saturation was reached around 14-15 interviews, but (just to be on the safe side) we analysed 17 interviews in a qualitative fashion, using a grounded theory method. Grounded theory is an inductive methodology in which "you start with individual cases, incidents or experiences and develop progressively more abstract conceptual categories to synthesize, to explain and to understand your data and to identify patterned relationships within it" (Charmaz 2007, 28). The researchers work inductively and draw conclusions based on the data. Conducting an analysis based on a grounded theory method means that open and tentative codes are given to sentences or parts of the transcribed interview. Afterwards, relationships between these codes are identified and codes are ordered under conceptual categories, or themes. During this analysis, we focused on added value of data sharing, obstacles and solutions that were mentioned during the interviews.

The remaining 16 (of the 33) interviews were analysed in a different way. As the initial analysis based on the 17 interviews had already reached saturation, it was not necessary to include more use cases in this study. The reason why we did this anyway, was twofold: (1) we wanted to get an overview over the data flows in all 33 use cases and (2) we wanted to know to what extent the remaining 16 use cases shared the opinions of the first 17 use cases. It is for this reason that we also analysed the remaining interviews, but we did this in a more general way. We noted the data flows that the interviewees mentioned in the table template for data flows. Next to that, we focused on the themes we had already identified during our qualitative analysis of the first 17 interviews and scored the remaining 16 interviews with respect to the support they give to any of these themes. This was done by listening to the recordings and reading the notes taken during the interviews. While most answers related well to the themes we already identified, we found a small amount of 'new' aspects in these interviews, which were added as slight deviations to the list with themes we already formed.

2.1.2. Flows of data

During all interviews with the use cases, we asked about the current data flows, as well as desired future ones. We asked about the actors who share data with each other and the types of data that are shared. To note current and desired data flows between actors, we developed a template. In this template we specified what types of actors shared data with whom and what type of data was being shared. Table 1 shows an example of a filled template for use case 1.1 (see Appendix C for tables of all use cases). On the left side you see a column of senders of data, on the top horizontal row you see the recipients of data. In the squares that represent the connections between senders and recipients of data, the type of data that is shared is specified. Types of data written in orange represent possible future data flows: these are the data flows that the interviewee would like to establish in the future.

In the table templates we used abstract terms to refer to the social roles of the actors as well as the type of data that is shared. Actors were divided into three main groups: business, public (organisations) and societal (non-governmental) organisations. As table 1 shows examples of actors included in the business category are farmers and tech providers. Public actors include universities and ministries or municipalities. Types of data include crops and seed data and soil data.

To characterize the types of data, we first used the EU code of conduct on agricultural data sharing and we used the progress reports to further refine the categories.[5] To characterise the types of actors, we used the MIT Practical Impact Alliance (2019) to form the basis of the categorisation of actors, and then matched it with the categorisation used in WP2 (D2.4) to refer to actors that are connected to use cases. Based on Pauwelyn (2014) and Curry (2016) we added missing agri-food actors.

Table 1. Example of a filled table

UC 1.1			Data receiver				
			Business		**Public**		**Societal organisation**
			Farmer	*Producer / tech provider*	*University and Research centre*	*Ministry / municipality / policy*	
Data sender	**Business**	*Farmer*		- Crops and seed data - Soil data	- Crops and seed data - Soil data		
		Demonstration farm	- Crops and seed data - Soil data (future)	- Crops and seed data - Soil data	- Crops and seed data - Soil data		
		Producer / tech provider	- Crops and seed data - Soil data				
	Public	*University and Research centre*		- Crops and seed data - Soil data		- Crops and seed data - Soil data (future)	
	Societal organisation						

Based on this, we shaped a draft list of potential actors involved in data sharing within IoF2020. Both draft lists (of types of actors and types of data) were presented to the WP leaders who provided feedback, after which the lists were completed. A glossary with an explanation of both the list of types of actors and types of data can be found in Appendix B.

[5] https://www.cema-agri.org/index.php?option=com_content&view=article&id=37&catid=19&Itemid=216

As we encountered many difficulties while filling the tables that represent data flows, we decided to discuss them with the WP leaders prior to taking a decision as to how to represent them in the tables. Our concern was that it was hard to show the complexity of data flows in a static table template. The main difficulties were:

- The transformative nature of data. Data undergo transformations in the sharing process; they can be raw data, processed data, they may be linked to other data and sometimes they are anonymised when they move from one actor to the next. This transformation of the data cannot be shown in the table template. Together with the WP leaders, we therefore decided to leave these transformations out of scope. The tables in appendix C therefore represent a simplified overview over the data flows and the types of data, without specifying any of the transformations of the data as they move from one actor to the next.
- The generalisation of the type of data. Once categorised as 'outdoor weather data' it is impossible to show that actor A shares different outdoor weather data with different actors; such as, temperature data with actor B and data about the humidity and wind speed with actor C. The tables ignore this complexity. Therefore, the table only shows traffic of for example 'outdoor weather data' or 'soil data' between two actors, but it does not specify further.
- Changing actors. We started out referring to organisations as actors. Usually use cases involved a collaboration of 3 to 5 different organisations. But sometimes use cases started to refer to their use case collaboration as an organisation. Interviewees referred to the use case team as an actor who is able to decide to share data with another actor, who was not yet part of the team. Eventually we decided to make this a topic for discussion during the interviews, in order to get a clearer idea about who in the use case decides (or is entitled to decide) to share what data.

3. RESULTS

The interviews gave us a rich and varied overview over the data flows realised in IoF2020, as well as the perspectives of use case coordinators on future data sharing options, their observed obstacles to data sharing and their views on appropriate ways to overcome these obstacles.

Regarding our mapping of current data flows we discovered that during IoF2020 most use cases only started to share data with actors who are already involved in the use case. They very rarely started to share data with actors who were not already part of the use case. Three use cases did not realise any data sharing between actors at all during the project.

The type of data that is shared depends on the actor and the purpose of the use case; for example, soil data (about nutrients in the soil) is shared in use cases that focus on crop growing such as arable farming or vegetable growing, but use cases that aim for better management of dairy or meat production farms will focus on data regarding reproductive and physical characteristics of livestock (growth, weight), livestock health or animal feed. Box 1 gives an overview over the types of data shared in each trial.

- Trial 1 Arable farming. Type of shared data is (a) crop and seed data, (b) soil data, (c) agri-supply inputs (d) outdoor weather data
- Trial 2 Dairy farming. Type of shared data is (a) livestock physical and reproductive characteristics data, (b) livestock health data, (c) livestock consumption data
- Trial 3 Fruit growing. Type of shared data is (a) crops and seeds data, (b) outdoor weather data, (c) agri-supply data (inputs), (d) water data and for the one use case on transportation of fruits: (e) transport items data and (f) indoor environment data.
- Trial 4. Vegetable growing. Type of shared data is (a) crops and seed data, (b) outdoor weather data, (c) agri-supply data, (d) field data, (e) agricultural product data
- Trial 5. Meat production. Type of shared data is (a) livestock physical and reproductive characteristics data, (b) indoor environment data, (c) transport items data, (d) livestock health data

Box 1. Overview of types of data shared in each trial

For all tables that represent the data flows in IoF2020 use cases, please look at appendix C (page 47). The tables give an impression of the type of actors that are most often involved as sharers or senders of data and those that are more often recipients of data. In most use cases, farmers share data with multiple actors, and receive data from one, or a few, actors. This however is not a clear indicator of how much information the farmer actually receives, for what farmers receive is often information that is based on a combination of data stemming from different sources/actors. After all, use cases often work toward the development of a farm management system that combines data to provide a service that is informative to farmers.

Actors that are most often involved in exchanging data (sending and receiving) in all use cases are businesses such as tech providers, commercial cooperatives (usually farmers and food processing industries in combination), producers (of for example farm equipment or machinery) and food processors, and in some use cases also logistic companies. There are also research institutes involved, which may be commercial research institutes as well as non-profit ones, and publicly funded universities. In general, these are the types of actors that are most heavily represented in the data sharing activities of IoF2020. Other public institutes beside universities are only incidentally participating in the data sharing network, such as policy makers/ministries or controlling bodies of the government. These actors are however sometimes mentioned as desired partners to share data within the future.

Societal (non-governmental) organisations and associations are also rarely involved. There is only one use case that shares data with an NGO, but otherwise, societal organisations are underrepresented in the data sharing network of IoF2020. Currently, there's also no data sharing activity with consumers in the use cases. Some use cases see this as a potential data sharing flow for the future, but they did not realise it yet.

Table 2. Overview over the number of times that a particular type of actor is involved as sender or recipient of data in IoF2020

Business	**Type of actor**	**Number of particular actors sending data**	**Number of particular actors receiving data**
	Farm	26*	24*
	Producer	4	5
	Tech provider	20	23
	Advisor	1	5
	Processor	4	6
	Veterinarian		1
	Supplier		1
	Logistics	3	1
	Distributor		1
	Retailer		2
	Wholesaler		
	Cooperative	4	6
	Certifiers / auditor	2	4
	Insurance company		
	Industrial research	1	2
Public	University and research centre	7	17
	Ministry/municipality/policy maker		1
	Regulator/controlling body of government		1
	Consumers		
Societal organisations	NGO		1
	Farmers' organisation		

**In this table, the number of farms involved stands for the number of use cases who have involved farms. Per use case the number of farms that have been involved varies from 1 to 40.*

Use case coordinators were also asked with what actors they would like to share data in the future. Table 3 offers an overview over these desired future data flows. It shows that many actors consider further expansion of the data flows they already have, such as an expansion of the data flows with farmers. Furthermore, many use cases mentioned wanting to share data with actors from the entire value chain. What stands out, however, is that 7 use cases would like to share data with consumers in the future, which they do not yet do. What comes forward as well is that use cases have little plans to expand their data sharing activities with public organisations or with societal (non-governmental) organisations. While there is some interest in data sharing with controlling bodies of the government and also in sharing data with universities, there is little interest in sharing data with ministries or municipalities.

Table 3. Overview over the number of times that a particular type of actor is mentioned as a potential future sender or recipient of data in IoF2020

Business	**Type of actor**	**Number of particular actors sending data (future)**	**Number of particular actors receiving data (future)**
	Farm	11	2
	Producer	2	4
	Tech provider	6	7
	Advisor		1
	Processor		7
	Veterinarian		3
	Supplier		1
	Logistics	1	3
	Distributor		3
	Retailer		4
	Wholesaler		4
	Cooperative	2	3
	Certifiers / auditor	2	4
	Insurance company		3
	Industrial research	2	2
Public	University and research centre	3	4
	Ministry/municipality/policy maker	1	1
	Regulator / controlling body of government		3
	Consumers		7
Societal organisations	NGO		
	Farmers' organisation		

In the following parts, we will present the findings related to the (1) added value of data sharing, including the value of expanded data sharing practices in the future, (2) the obstacles encountered regarding data sharing and (3) the solutions that came up to overcome these obstacles. As will come forward in the results, however, use case coordinators have almost only been talking about farmers in relation to data sharing.

3.1 Reasons to share data and added value of additional data sharing

When asked about the added value of data sharing, respondents had a lot to tell. When asked about the value of data sharing, respondents sometimes referred to the value of the content of the data shared, and sometimes they focused on the activity of sharing as having value, and oftentimes they jumped from one approach to the other during the conversation. Therefore, we here chose to consider both at once, as the value of the data and the collaboration are approached in an intertwined manner. In the following we present the themes that come forward most prominently in their reflections about the value of (additional) data sharing.

3.1.1 Enhancing knowledge to improve business activities

Respondents most often did not talk about the value of data sharing for them, but primarily talked about their customers; primarily farmers and growers. One of the great advantages of sharing data with other actors that respondents often bring forward is that data strengthens knowledge, which helps to improve farmers' and growers' business activities. Acquiring more knowledge can have different business advantages: it can help farmers/growers to optimize their products or processes, improve their competitive position in the market, save time and/or money by making farm processes more effective or reducing the inputs (such as, water, fertiliser, feed for animals, pesticides etc.) needed to realise a good level of production.

Depending on the sector and the specific focus of the solution, the knowledge that can be obtained based on data has an impact on many different activities which are important to make the farmer or grower's business successful in realising a satisfactory level of production effectively.

Optimization of products and processes

One of the advantages of data sharing is that it helps to optimise products and processes for multiple actors. Data sharing enables farmers or growers to anticipate in advance what the quality or quantity of their production will be in that year or season. However, to allow a digital technology to anticipate that in a reliable manner, some respondents indicated that they needed farmers to collaborate with them and share data with them. When farmers allow to collect data at their farms, and consent to share their knowledge which helps to check whether the interpretation of the data is correct, use cases can train the model behind the solution to make better predictions and realize a well-functioning technology. Eventually this will benefit the farmer who is to use the technology, but also the developer of the technology who will have a better product to sell.

> "(...) So it was, most of the time I think, beneficial for both sides and our motivation was, or is, always to improve our product. So if we have more data that we can work with, we have a better basis for the decisions of the growers." – Arable trial

A reason to add more farmers/growers to that data sharing network has different advantages: the solution will improve and it will provide better knowledge to farmers/growers. Connecting to data from multiple farms will allow to enrich the knowledge of farmers which is usually just based on one farm. Multiple data sources stem from multiple farms which produce food in different contexts and conditions. Based on that more general knowledge, which is based on data from many farms, farmers will be enabled to make better decisions: it will allow the farmer to know in advance what consequences cultivation actions will have on their product.

> "[T]he farmer [...] can know more. For him it is also better, for he can steer even more, or [anticipate, EG] what effect a certain action has on the size of the potatoes for example." – Arable trial

Combining the data that represent the knowledge of many farmers, will eventually serve every single farmer: it will provide knowledge that offers them the opportunity to have more control over the quality of the products they realise. Concerning the optimization of processes, interviewees mentioned that data sharing could make them more efficient: decisions could be improved, as data allows to plan business activities in advance and anticipate and tackle possible problems earlier. For example, by sharing data, decisions can be tailored to the needs of crops or animals in specific circumstances, which allows to work in a more precise manner and make less mistakes. Eventually, this is expected to save money.

> "A factory that (..) keeps an eye on machines in a structured way saves tons each year. (...) and if you measure in a dairy factory where millions of litres are being processed, then (..) you can really save tons on an annual basis. So, our tool does cost something, but because it allows them to work more accurately, they will earn it back." – Dairy trial

Another example mentioned by interviewees is that data sharing can help to reduce the investment of time (and money) as it makes paperwork and/or consultation of people obsolete. This could for example concern confirmations of the delivery of products, but also prove of meeting certification standards. Farmers can share data about the amount of pesticides that has been sprayed on the field or the type and amount of (biological) feed that has been given to cattle. Furthermore, interviewees mentioned that anticipating, preventing or solving problems in the supply chain also helps to improve collaboration and therewith optimize the processes.

> "We checked for them, for example, for how long pallets have been staying in warehouses. Because, every day a pallet is staying, costs money. Pulling pallets should move and not stay. And there were some people getting information basically on where to look; at which locations to check that pallets are exchanged and these types of things. So that is the information we are sharing with the customers, and these customers want to have the information." – Fruit trial

The optimization of processes can focus on the exchange of objects (such as pallets) but also on the realisation of a more fluid and effective collaboration between people. Farmers can, for example share data with veterinarians, which will help them set a diagnosis. Furthermore, it can help veterinarians to monitor the health of animals without having to visit the farm, which saves time and money. In addition, farmers could share data of various sorts with experts who can give them advice, such as, agronomists, researchers at universities, cultivation advisors or even with colleagues such as other farmers/growers. This advice allows farmers to improve their cultivation or breeding strategies, which can help them reduce their time investment and enhance the quality or quantity of their yield. Sharing data can furthermore help to broaden the number of people from which farmers get advice; it allows to build on the expertise of many people. This will be helpful, as it would be impossible for every farmer to collect that knowledge by him or herself alone.

> "For farmers it is important that there is data at all, so that they can get cultivation advice. That is why they share their data: to get advice." – Arable trial

The optimization of products and processes are important reasons interviewees bring forward for the envisioned end-users of their products, such as farmers, growers or actors in the processing industries to

share data. Interestingly it is also the primary reason why they think these end-users should be interested in the products that the interviewees develop in the use cases. These arguments for the added value of data sharing can therefore also be seen as the primary advertisement for the product they are developing: they consider it attractive for monetary gains.

Improving competitive position

Some respondents also considered the possibility that data sharing helps to strengthen one's competitive position. IoT developers and manufacturers, for example, mention that sharing data enables them to show the added value of working with their solution or machinery, compared to not working with that solution. They would like farmers to see that it helps them to be better than their competitors.

> "And the manufacturers of farm machinery share data because they really want to be leaders in planting and harvesting of potatoes. (...) They want to show that. They want to point out that they are better compared to the competitor." – Arable trial

Interviewees also think that sharing data can help farmers or other agricultural entrepreneurs, to distinguish themselves from competitors. They specifically bring forward that it is helpful for farmers to share information with consumers. Giving consumers access to data that allows them insight into the way crops are grown, or how animals are treated at a farm, will allow them to appreciate a product more: farmers can show why their products are better compared to the products of others.

> "Sharing data with consumers allows farmers to underline the competitiveness of their product. (...) So again, in our view, it is a way to share with consumers the investments they [farmers, EG] make on their farms in order to provide a top-quality product for consumers. And secondly, they can share cultivation practice details, like data that show that they fertilized or that show that only on those days I irrigate, or I did not apply any pesticides one month before harvest, for example. (...) So again it is a matter of unveiling the responsibility taken for the sustainability of their land." – Vegetable trial

The presupposition of these respondents is that consumers are willing to pay a higher price when they know where food products come from and how they are produced. Sharing data with consumers is a prerequisite for that. This would, according to some of our respondents, be an added value of data sharing that could come about if farmers would be willing to share data with consumers and if consumers would be willing to take data into account prior to making their purchases.

3.1.2 Enhancing knowledge for public purposes

Besides the fact that, according to interviewees, data enhances knowledge of end-users such as farmers and growers which helps their business activities, it can also benefit public purposes. The ideas on how sharing data could be beneficial for public purposes were diverse. Some respondents mentioned that it could be useful to share data with public authorities to show compliance with the law in a precise, easy and efficient way. Sharing data for this purpose saves time for farmers, who often have to do a lot of paperwork in order to point out that they respect the law. Furthermore, sharing data could have advantages in terms of reliability. During for example checks on the level of nitrogen emissions, a

respondent indicated that it would be easier to extract nitrogen emissions from machine data. This data might be more reliable compared to the current means to measure nitrogen emissions.

Next to that, interviewees also mentioned that data sharing could be used for other public purposes, such as sustainability goals: data can for example help monitor the ecological performance of supply chains, or they can help to show how smart farming technologies help to save resources such as water.

> "For example, we have collected a lot of data on location connections [...] we could create some kind of benchmark. But this is an anonymized benchmark so it has no data sharing in the sense of 'here is my sensor and I publish my data', this is more making it available for example for ecological evaluation of supply chains. How many kilometres fruits and vegetables actually travel [before they reach a consumer, EG] and these type of things." – Fruit trial

Furthermore, data sharing can also foster more societal acceptance of food production and better research. Sharing data with researchers, for example, can teach researchers about the difficulties that farmers and growers encounter, which allows them to tailor their research to the actual farming practices. Consequently, this could help to narrow down the gap between scientific research and practice.

Data about food production can also be shared with the consumer, thus enhancing the awareness of consumers about production processes and the effects these may have on the environment, animal wellbeing or on human health. Consumers obtain more knowledge about the food they consume which allows them to take their health into account when they make their purchases, which also helps to elevate public health.

> "It is making them [the consumers, EG] aware of... I mean when you eat (...) you insert food in your body. And yeah we all live with our body and mind so if you don't treat it well, it starts to become an issue. (...)All these snacks for example, maybe they are unhealthy, but it doesn't kill you if you eat it in the right way. And then there is someone else that sell[s] you super fancy vegetables, because they're healthy but then you also take in pesticides and they are more dangerous than a snack. So, it's creating, I think it's creating knowledge and awareness about what you eat." – Fruit trial

3.1.3 Instrumental value of data: earning money

Data can also have instrumental value, which means that they have value as an instrument towards getting something else that has inherent value. The most prominent example of data having instrumental value, is when they are used as 'payment' to get something else. The idea of some use cases is that actors can directly earn money by sharing data, for example by selling their data or earn revenues, which increase when numbers of people using their data go up or when they are used over a longer period. In our interviews, we did not hear of any actor that at present directly earns money in exchange for data. However, some respondents considered this a possibility for the future.

> "[W]e kind of looked for a preliminary model where farmers would be able to monetize their data so that there is kind of data centralization. So, based on how many people use their data, how they use the data or how long they use the data, farmers would be getting like a (...)

revenue. So that was supposed to be integrated on block chain, but now we have put that on hold until we finish the regular, like the normal side of it." – Arable trial

3.2 Obstacles to data sharing

While all respondents could name multiple reasons to share data, not all of them did actually share data as frequently as they would like. Many different obstacles and hurdles were observed to be hindering further data sharing. In the following part of this paper, we present the obstacles mentioned by our respondents. We divided the obstacles in five parts; (1) added value of data sharing is unclear, (2) lack of trust in data sharing, (3) financial obstacles, (4) legal obstacles and (5) technical obstacles.

3.2.1 Added value of data sharing is unclear

While our respondents agree that data sharing can have a lot of advantages, they also point out that the exact benefits of data sharing are unclear for many actors involved. Some interviewees blame this on the fact that data sharing in the agri-food sector is a relatively new phenomenon. The benefits of data sharing are likely to materialise in the future, but for now these benefits are not clear yet. According to them, it takes some time before data sharing is more embedded in the agri-food sector and before the added value of data sharing becomes clearer for the actors that are involved.

When stakeholders do not see the advantage of data sharing for themselves, the reasons to resist data sharing often tend to weigh heavier in their decision making. Data that is collected on farms can contain sensitive information about the business, about yield or processes on the farm which are sometimes considered 'trade secrets'. Farmers and growers need to see an advantage for themselves before they decide to share their data. When they don't see the advantages of sharing data, the data will probably not be shared. Data sharing will then remain a side issue, instead of a priority for their business. For agricultural entrepreneurs, it can feel like sharing data is too risky for their own business.

> "We measure a lot of samples (...) from their [the farmers', EG] production. And that is really valuable data (...). That data is a little sensitive. (...) They do see us as a trustworthy, independent company (...). They do not think that we would share the data with others, but they do not immediately see the added value to sharing the data with us either: 'Yes why should we take the risk at all, just leave it [the data, EG] with us'." – Dairy trial

During some interviews, respondents mentioned that most farmers desire a short-term win or short-term benefit. The agri-food value chain is a low margin market, short-term financial gains are therefore often prioritised over long-term financial or societal gains. Farmers often have to invest time and money in getting the right digital infrastructures in order to properly share data. If it takes a long time before they see benefits from data sharing, many farmers will decide not to do it.

> "If we talk about the food market, it's a low margin one. (...) There are very few people that are visionary or say okay let's create a better world. There are a lot of people that say: what you're doing is very cool but first please let me do what I have to do to be paid and then let's do this [share data]." – Fruit trial

3.2.2 Lack of trust

Not only is the added value of data sharing unclear according to interviewees, certain actors also lack a level of trust that is needed as a basis for data sharing. Respondents argue that for some, lacking trust does not have anything to do with the type of data-recipient. Some lack trust when it comes to sharing their data with anyone. They are 'scared' by the concept of data sharing because they do not have a full understanding of what data sharing actually entails. Some respondents point out that this could be a cultural issue.

In certain countries, the idea of data sharing immediately calls for objection and aversion. Time is needed to embed data sharing in agri-food sectors and in the society at large. One example given during the interviews is that Greek farmers suspect that data sharing leads to extra costs. Another example that respondents brought forward is the mentality of Spanish people, who generally prefer to keep information to themselves. Even if Spanish farmers are convinced that sharing data will have benefits for them, they often still decide not to share data with other actors in the food chain.

> "Farmers that are participating in [the] use case, [they] don't want to share data because in Spain (...) [the] culture, the mentality is different. The initial idea is 'I don't trust the other', they don't want to share data. I think during the project they grow more convinced that data sharing may have benefit for them. First [a] farmer says 'good idea', but when they need to share data, they stop. We also want to do this work in other countries, I don't know what happens there. But in Spain they want to share data with consumer[s], but not with other agencies in [the food] chain." – Meat trial

Not all actors don't share data because of this basic resistance against the idea of data sharing; some actors lack trust in (possible) specific recipients of their data as well. The idea that when data is shared, others can decide who gets to see the data and what is done with the data is an obstacle for many farmers and growers as this would mean they are no longer in control over the data that have been collected on their farm. There can be a certain fear of what others will do with the data. Some actors are afraid that the data might be misused, meaning that they are used for other purposes than they originally agreed to or by using it in ways that can eventually harm the sharing actor.

When data is shared with governmental institutes, the data can be used for the development of regulations with which the data sharer disagrees, or which has negative impacts on him or her. Use cases argued that this worries not only farmers, but that other companies in the use case may also be concerned about it.

> "So yeah, it can always be misused (...) Some say, I do not want that everything is on the streets just like that, because who knows that can be extracted from it. (...) Maybe individually it is not a problem but on a larger scale you can maybe extract more [information] that could also make regulations more strict or adapt it, which has negative consequences for the user. (...) In general, there will be more rules if they get more knowledge than less rules." – Vegetable trial

Besides unwanted and stricter regulations, farmers are also afraid that when other – usually larger and more dominant – actors get to see their data, these actors have more power to determine or adjust prices

they get for their crops or products. The more other actors in the agri-food chain know about yield prospects, for example, the more they can determine what price farmers get for their crops. While it can be an advantage for these companies to receive data and set prices beforehand, this usually affects the farmer negatively. Our respondents argue that this is one of the reasons why that farmers want to stay in control over 'their' data.

The lack of trust between different actors can – according to our respondents – be partially explained by the fact that people do not know other actors in the data sharing network. Especially when data flows are more complex and many partners have access to and do something to/with the data, the original sender sometimes finds it difficult to have an overview over their data, or influence what happens to data. In the interviews use cases described that since data sharing does not require physical contact between partners, it can feel like an abstract and anonymous act which forms an obstacle for farmers to share data.

3.2.3 Financial obstacles

Respondents indicate that there are financial hurdles or obstacles that complicate the sharing of data. These hurdles can be divided into financial risks as a result of data sharing and costs of data sharing itself.

Financial risks as a result of data sharing

Financial risks as a result of data sharing are often mentioned during our interviews. Respondents indicated that actors worry that the value of the data diminishes when data is shared because they regard data as something that can be owned and has a value that decreases when more people have access to it.

Actors sharing data can be harmed when their competitors have access to these data. Even though data may not be shared directly with competitors, they could be provided to them by third parties or by the farm management service itself which has been 'fed' with knowledge obtained from different farms. When competitors, for example, learn about a business strategy via a farm management system, they can adopt the same strategy.

Respondents also informed us that contributors to the value-chain are also often reluctant to share data with consumers. Sharing data with consumers could have positive or negative effects on the market position of a business. Consumers' attitude towards a product can be negatively affected when they see data about the way a product has been cultivated, produced or distributed. Therefore, companies feel like they need to think carefully about the types of data they will want to share with consumers, and which ones not.

> "If you see that [on] the shelf of the supermarket (...) something that says to you: 'hey this (...) fish has been 10 hours out of the fridge', you will never buy it, obviously. You will choose a different product. (...) So no one wants to share real data with the consumer, everyone wants to share *the right* data with the consumer." – Fruit trial

The whole value-chain may be affected when data are shared which produce a negative customer attitude toward a product. When customers no longer want to buy the product, this will bring down sales. The entire value-chain may be harmed by this, even when some participants in the chain did nothing to deserve a negative consumer attitude to their product. Sharing data may therefore also make the financial

success of every partner in the chain dependent on the actions of everyone else. Not all contributors to a value-chain are prepared to make their success depend on others. Sharing data means becoming more transparent, which decreases control over the consumer acceptance of one's own products, which can cost money.

Data sharing costs money

Besides the above-mentioned financial risks, respondents also mentioned that sharing data costs money because companies need to have access to the right software to (easily) transfer data. Farmers and other actors first need to invest in this software. Some farmers already have access to software with which they can share data manually. Having the opportunity to automatically transfer data would be preferable since it requires less human interaction and therefore saves time. However, automatizing data exchange is costly. Furthermore, this software does not only need to be bought, it regularly needs updates as well. As quite often the (financial) benefits of sharing data is hard to foresee, farmers are reluctant to make the necessary investments: they don't know whether the benefits weigh up to the costs.

3.2.4 Legal obstacles

Under the theme 'legal obstacles', we ordered the quotes from interviewees who discussed problems related to having either too little or too much legislation. According to some, stakeholders feel uncertain to share data, because there is insufficient legislation that protects their data rights, such as rights regarding data ownership, or a law that protects business data which do not fall under privacy law or competition law. Others, by contrast, bring forward that legislation which is already in place occasionally hinders data sharing.

Lack of legislation hinders data sharing

While there is a General Data Protection Regulation (GDPR) that protects people's personal data, some respondents feel that this does not offer enough protection. Some call for more protection of business data, which are not private but need protection nevertheless. They feel that the data they gather is sensitive and could be considered 'private' even though they are not personal data. The European Code of Conduct of agricultural data sharing by contractual agreement (EUCC) was designed to offer protection of these non-private data. This was done by means of ownership ascription to the persons from whose land or business the data stems. According to many respondents, however, the EUCC does not offer enough protection.

During the interviews, respondents discussed the control of actors over data. Many respondents used terms like 'data owners' and 'data ownership', to suggest that data can be possessed by someone. It however also appears to be unclear who the owner is and what data ownership actually entails. According to some respondents, the owner of the data is the one who has the right to decide about data, including with whom data is shared. But it is not always clear who has that right. Most respondents argue the farmer or the grower from whose land the data is gathered is the owner, while others consider the company who makes the IoT solution that collects the data the owner. Furthermore, when data are shared and different people do efforts to process them and connect them to other data in order to use them as a basis for knowledge, it is unclear who will be the owner of the data after that.

> "[It is] unclear to whom the data belongs. Does the data belong to the farmer? In our case, the data does not belong to the farmer because the farmer does not purchase the system. Feed transporters rent or buy the system (…) [Is] the system owner, the owner of the data? [It is] unsure who can eventually share the data. If the owner is not known, it is unclear who eventually has to pay for the data. As long as this is not clear, we cannot continue to develop [the IoT solution, EG]. We are not taking the risk to (…) sell systems and subsequently receive claims for damages because you do not live up to privacy policies." – Arable trial

Some people ask for more clarity about data sharing in regulation, for they want to settle who is to decide about it. Others do not want such regulation, as they expect that settling the question who owns data, will also make it more difficult for others to decide to start sharing data. Those who do not own the data therewith lose their right to decide about them. Some respondents argued that it would be unfair to share data that they do not own. Doing that would harm the relation they have with their customers, which are farmers for a tech developing company.

> "No, we are not sharing data with anybody because… we have the opinion that the data belongs to the farmer. (...) We don't feel that we have the right to deliver these data to anybody… that would only be in an anonymized form where you don't have these ID's here. (...) If we have started to do this, we would lose our trust from those who are our customers. (...) Farmers should feel they can trust the data that are collected in the IOT systems that they have bought. (...) We need to have trust from the end user." – Dairy trial

Since not all farmers want to share their data, ascribing data ownership to them often means introducing an obstacle for (additional) data sharing. Respondents observe that not all farmers want to be bothered by questions about data sharing. Some farmers are keen to help to foster data sharing, but most often farmers are not eager or are even reluctant to share data, especially sensitive data, like financial data. Ascribing data ownership to farmers will therefore probably make it more difficult to make data flow more freely.

Existing legislation hinders data sharing

Some respondents observed that some laws form an obstacle for the sharing of data. One respondent argued that the European competition law, which protects companies in a supply chain, hinders data sharing. As some data could impact the free competition on the market, this law forbids them to share these data.

> "The problem is, that we always have to take care about who else can have the data and who not. (…) We collect al lot of data along the whole value chain and some of the data is really sensitive for the competition in the market, so we are not allowed to give it to other partners." – Fruit trial

Another obstacle for sharing data are the different kinds of regulations that are applicable in different regions or countries. Many countries have (slightly) different regulations or guidelines regarding competition, land-use, crop choice or environmental protection, which makes it harder to cross national borders when sharing data. Also within countries, different regions or provinces sometimes have different

regulations which makes it hard for actors to find their way and meet all regulations that are in place. When regulations or ways of organising differ for regions, it can be hard to find the right people or organisations to share data with, as one respondent experienced in Italy.

> "In Italy we have a number of regions and farm data is managed by regions in different ways, so there is not a national standard. The problem [to share data] is to speak with the right person in each region and in Italy we have 20 regions. An example is the cadastral data. Each Italian vineyard is recorded [and] for the vineyard we know the variety, the density of planting, the owner of the farm. This information is stored in a database. Another database contains information about pesticide application and farming. Another database contains information about production... databases do not communicate easily." – Fruit trial

3.2.5 Technical obstacles

Technical obstacles to data sharing were also a recurring theme in the interviews with use case leaders. Data sharing requires availability of technology and connectivity, as well as standardization in the ways data are collected, processed, stored and exported. Therefore, a certain kind of technical software and hardware needs to be present at a farm or other company. Since this is a relatively new development in the agri-food sector, this causes some obstacles. We divided these obstacles into two different subtopics; the absence of standardization in gathering and exporting data and the technology in the sector that is lagging behind.

Lack of standardization

Data sharing in some cases is hindered because there is lack of standardisation in data formats, semantics, software and ways of exporting or receiving data. When the data that is collected in different formats, stored in different ways or different software is used, the exchange of data is complicated. When farmers, for example, want to share data with their suppliers and they all use different software, data sharing becomes difficult.

> "For the slaughterhouses, especially in the Netherlands, it is arranged fairly good. You have an AD rapport and that actually is a pretty standardized format. (...) In Belgium they cannot get that standardised or automatic at this moment. (...) You can look into things, but exporting data... Yes I think that is still difficult." – Meat trial

Since there are many ways nowadays in which data can be collected, stored and exported, it is hard for companies to decide which format to use. It is inefficient and costly to work with several standards at once, so companies have to decide what standards to use. Especially for small, starting companies, it is hard to decide which standard "is the winning horse in the race" (Fruit trial). Larger companies usually have more financial room and therefore flexibility to change towards a different system compared to small companies.

Besides taking time and costing money, working with different systems makes it harder for people to understand what actions they have to take to share data. When systems (slightly) differ from each other, it can be hard for some people to understand the differences and work well with all systems.

> "Technology suppliers all have a different approach and all a different software (...). So many systems and if the pig farmer by accident adjusts one thing or when there is a software update or something, then it is all located somewhere different and you can start all over identifying which data belong to what." – Meat trail

Secondly, due to the lack of standardisation, systems are difficult to connect. For a fluid exchange of data, it is important that the sending and the receiving technical systems are able to 'communicate' with each other. In order to work with the data, recipients of the data need to be able to read the data correctly and perhaps work with it in their own systems. The lack of standardisation of technological software in the European agri-food sector is seen as a big hurdle for the realisation of data sharing, as well as for the success of digital farming in general.

This issue was also discussed in relation to the need to cross borders of EU member states. Some countries or regions in Europe have their own software or systems, which complicates the communication of data stemming from different areas.

> "In Denmark we have a system, (...) we already have [a] protocol for how we collect these data (...) [And] we are already working in Germany, and in Germany they don't have such a system. Germany has sixteen Bundesländer and for each Bundesland, you have a different system." – Dairy trial

Technology in the sector is outdated

Some respondents bring forward that the technology with which a lot of rural actors are working, is old-fashioned and unfit to run sophisticated farm management services. Many respondents brought forward that a lot of farms do not use a lot of digital technologies: they are not frontrunners when it comes to technological developments. Some respondents question whether this is because of the rural identity of the sector, or "because the farmers and the persons related to this kind of sector tend to be older than in other sectors" (Meat trial).

Many of the digital systems with which farmers work are not able to extract data automatically and frequently. Respondents mention that the technology used in the European agri-food sector is developing, but that it still needs further developments and investments.

3.3 Solutions to foster data sharing

Respondents generally answered rather quickly when we asked them about the added value or the obstacles of sharing data. But suggesting solutions to overcome barriers (or stand-alone measures to foster data sharing) seemed to be more difficult. Although some interviewees had quite clear ideas on this topic, others needed time to think or to (clearly) formulate their solutions. Nevertheless, all solutions mentioned by respondents – extensive or not – mainly covered four different themes: clarification of the added value of sharing data, legislation or regulations, technical solutions or standardization and a change in (data) cultures.

3.3.1 Clarifying the added value of sharing data

One solution often mentioned by interviewees was that the added value of data sharing should be clearer.

They suggested two ways of doing this: by explaining and informing potential data sharers of the added value of data sharing or by offering more incentives to start sharing data. For a lot of respondents, however, there is but a very thin line between informing and incentivizing.

Explaining the added value of data sharing

According to some interviewees, the benefits of sharing data are – to a certain extent - already there, but the involved actors are not aware of them. Therefore, they think it is important to explain the benefits of data sharing. In other cases, interviewees mentioned that actors like farmers are suspicious of what other people will do with their data and simply explaining them what data sharing entails and what the purpose of data sharing is, could help.

> "There is a need to tell 'what is data sharing'. If you ask: 'do you want to share data?' They say: 'no', because they don't know what data we want to share. They should get something in return. This is also an important part of education." – Meat trial

As explaining and informing farmers is a time-consuming job, we also inquired into the possible roles for data platforms in this respect. Some platforms have as their specific aim to create enablers for data sharing and could perhaps also take a role in informing farmers about data sharing. Some respondents considered this possibility and thought these platforms could reveal more of the benefits of data sharing for different parties and provide farmers a share in those benefits. They considered this a straightforward way to inform farmers, but also a way that actually allows them to experience the benefits it can bring them.

> "The data goes from A to B and the data has value for party B, so how do we make sure that some of that value flows back to party A? Of course, such a platform does not yet do that [show the value for the farmer, EG] today. Okay, then if we have such a business model, or models, maybe several, then maybe we also need to get a platform like this somewhere that runs that automatically, in one way or another. If they also get that data [about the value of data, EG] (...) those values then flow back to the farmer (...) That can also be something very stupid, a ticket of euros that add up." – Arable trial

Platforms like Joindata or Djustconnect want to show what advantages farmers can receive by sharing their data with different actors, but some of the interviewees indicated that the added value is not yet visible for farmers on those platforms. For example, when a farmer shares data with company X, company X knows what the value of that data is for them. However, farmers do not know about this. Making this value of sharing more transparent and visible to farmers, for example by showing them how much money is saved by sharing data, and how much money they as farmers will get, could not only give them the necessary information but at the same time also give them incentives to start sharing data. There seems to be a thin line for respondents between the provision of information and provision of incentives.

Providing incentives for sharing data

Interviewees thought that current data sharing offers not enough immediate benefits and therefore

suggested to add more benefits as incentives. This would motivate farmers/growers to overcome the obstacles, as they would have a clearer view of the wins it brings for them.

> "It is a matter of incentive, for what would be the reason behind it? Why would a farmer want to share with another farmer? If they are already partners then there is reason to do it and then technology should provide this function [to do it digital, EG]. But if competition plays a role, then they want to protect their ways of doing things. So, I think there should be a good incentive in order to foster data sharing with other actors." – Vegetable trial

Most respondents suggested to provide monetary incentives as a way to foster data sharing. According to them, farmers and other actors would not be as hesitant to share data when they would earn money with it, directly or indirectly. This could be done by means of tax incentives or subsidies, or by simply paying money in exchange for data. Other possibilities that respondents mentioned were the provision of cost reductions for specific services such as maintenance of hardware. Or some respondents mentioned that in order for farmers to share data with for example insurance companies, certain coupons could be provided or a reduced insurance premium which could function as a motivator to share data.

> "I am quite sure that if they [breeders, EG] get money in return, that then they'll share data. More than 90% of them is going to share data. Because in the end, in our case, we want to share the calf interval time [the time between the birth of a calf and the insemination of the mother for a new calf, EG]. This is something that is quite general and mandatory, because the date of the birth of a calf is mandatory to record. You don't need to share this data with us but it is not personal data and they need to register it anyway. If a farmer receives money back or gets a discount, (...) then for them it is okay." – Meat trial

Others mentioned incentives that did not have (direct) monetary value but could also function to improve the societal reputation of farms. A good reputation is important for farmers, as their business can only thrive if consumers and the public at large accept the way in which farmers work. Sharing data bears with it a risk for that public reputation, if it means that information will be shared that could harm that reputation. Some respondents therefore suggested to make it more attractive to share those data, by making it less dangerous to show information. They suggested, for example, to allow slightly higher nitrogen emissions when farmers share data to show compliance with the law. Given that farmers are often afraid to be penalized for having slightly higher emissions when they share data, this could reassure them and function as an incentive to start sharing these data. Furthermore, an incentive could be that farmers get more information about their customers when they share data: for example, farmers can share information about their products with the consumer and can benefit from that if they are consequently allowed to get consumers' opinions and product-ratings in return. This could be an incentive to start sharing data, as it allows farmers to attune their production methods and products more to the values and wishes of consumers.

Some interviewees thought that the societal reputation of the agricultural sector could improve when companies along the supply chain (e.g. farmers, food manufacturers, food processors) show their effort to serve public goals, such as the protection of food safety. Improving their reputation in this respect could also serve as an incentive to share data. During a food safety crisis, for example, sharing data could help

to track contaminated or dangerous food products, or prevent the distribution of these products to retailers. When the product already reached the retailers, they can also prevent purchase or consumption of these products by consumers, as it is easier to find out where they have gone and call them back. In these situations, data sharing could contribute to a larger, societal, goal, but it also protects their own good name as a business that takes care of food safety. Therefore, some respondents think it could be used as an incentive to share data.

> "So if there is a good reason to do so [share data, HA], for example in a food safety crisis or something, then this would be something .... then you would be considering opening up to a certain part of the network to be able to follow [the contaminated products, HA] (...)through the network and where .... [they are, HA] for example, that would be in collaboration with authorities." – Fruit trial

As food safety is a public goal that touches the interest of everyone, farmers want to collaborate to protect it. And their company will get a bad reputation if contaminated food comes from their farm. Collaborating to take care of food safety, will therefore help to secure the good name of their farm. Therefore, doing this will benefit them and is considered an incentive to share data.

3.3.2 Regulation or legislation to foster data sharing

Many interviewees thought that the development of (additional) regulation should play a role in fostering data sharing. They did different proposals: such as, making data sharing mandatory, making the use of certain systems mandatory or regulation clarifying the rights of data owners. Most of the respondents thought that the government is primary responsible for establishing legislation, as well as regulation and protocols, but some of them also thought that companies and/or cooperatives could take a role in doing this as well.

Making data sharing mandatory

According to some respondents, data sharing could be fostered by making it mandatory by law, or by means of regulation and protocols within cooperatives or companies. Others, however, were doubtful whether obliging people to share data would have the desired effect. According to them, this would force different companies to try and look for a short-term solution themselves, rather than creating such an ecosystem in collaboration.

> "I think that before making it [data sharing, EG] mandatory an ecosystem should be build. Because if you make it immediately mandatory then a mess starts because everyone starts looking for a solution. Then the market breaks because there is this big consultancy firm that says, 'this is the way to do transparency'. Then there are a lot of food companies that call the cousin or the brother that develop a piece of software, but it's not, I mean, it is something to do by which you comply with the law but it is not something that is healthy for the system. So maybe before building an ecosystem [we should think about, SvdB] value and knowledge. This kind of ecosystem should be built with people that really believe in it, not only because they make money." – Fruit trial

Other interviewees suggested less drastic ways to foster data sharing, such as by enforcing the use of more transparent data systems. These data systems could encourage farmers to share data as they give a clear overview over who has access to the farmers' data and for what purposes data are used. Another solution brought forward by interviewees was to oblige farmers to use a (standardized) digital data format to meet quality standards. This would also stimulate farmers and growers to share their data.

> "Subsidy but also, for example, making the use of systems compulsory, I think that exists in the Netherlands. Systems in which the farmer can see very well who is using the data. So that it also becomes transparent, (…) that the data flow of the farmer is also very clear; who does what with my data. (..) The government certainly has a role to play in this." – Arable trial

Adapt or create additional regulation

Interviewees often mentioned that there is lacking legislation. While there is EU legislation that protects privacy, different interviewees mentioned that this does not provide enough guidance for their particular dealings with data, such as the following respondent who explains that it does not show how to deal with some of the business data.

> "We are collecting data on business to business relationships. And this business is not part of the data privacy regulation, which is for personal data and not for business to business [data, HA]. Business data is regulated differently. That might be also a point to take into account for the EU, how to deal with business data." – Fruit trial

Or the following respondent who says that farm data do not fall under any legislation that indicate who is entitled to do what with the data.

> We have the GDPR, but here we have data that belongs a bit to everyone. Sooner or later you will run into a problem. If there is clear regulation [for farm data, HA], we can use that to allow or deny access. Today it is not completely clear yet." – Arable trial

Some respondents suggested that it would be good to have regulation that clarifies data ownership. Such regulation would make clearer who the owner is of the data and allows to determine who is entitled to benefit from the data or make decisions about whether data should be shared and with whom. Creating clear regulation regarding data ownership, would allow farmers and other actors in the data sharing network to know better what is due to whom and why. Furthermore, it would help to clarify what counts as misuse of data and prevent it. Some suggested that it should be the government's task to develop such regulation, in the form of laws. Others suggested that regulation and protocols that set a standard for how to deal with data, could also be developed within companies, cooperatives or data sharing communities. They could for example establish rules regarding who is to benefit from data or signed agreements that reveal who has permitted access to the data. Respondents, however, had little ideas as to the content of such regulation or protocols, or how they should be shaped.

3.3.3 Standardization of data (systems)

To facilitate data sharing, many respondents suggested that standardization is needed of data formats and/or data systems. Data formats often differ in terms of data types (language, abbreviation), file types or the order of the data in the file, complicating the exchange of data. Standardizing these formats can

facilitate data sharing by increasing readability and possibilities to connect and/or merge data files. In the following quote the respondent illustrates this lack of standardization by using different words to refer to the same thing, such as temperature or temp,

> "Perhaps there should be agreements about what data should look like. When eventually these are available, whatever it will be, that does not really matter. But it should be aimed at, yes, the export, that you can automatically retrieve them, via an API or something. But apart from that, there is a lot to do about standardization and data models and the like, but whether we call it temperature or temp or whatever, well, as long as we know what that means, we can do something with it and that will not change from day to day, of course. What that is called and in what order it is put." – Meat trial

Not only standardization of data formats was mentioned as a technical solution, but data platforms could also use standardization. Several interviewees expressed their concern about the number of available data platforms, which cannot easily be connected. If there are many different platforms available within countries as well as internationally, it will be hard to connect data streams or get an overview over available data and the actors involved in sharing them. If most meat farmers, for example, would use the same data system, it makes data exchange between these farmers and other actors in the value chain, such as the slaughterhouse, easier. More standardisation, in different ways, could therefore ease data sharing.

> "In the Netherlands there was a protocol in the '80s for different systems to exchange data. But that is not very well documented and old. A modern platform should be formed where anyone can become a knowledge broker. It has to be done by a consortium and has to be global." – Dairy trial

Most interviewees think that European or national governments should take a role in fostering standardization. But few had other ideas about this. During one interview, a respondent mentioned that private companies should take care of standardisation and mentioned a private organisation that is already working on the standardization of data exchange by developing a worldwide protocol for sharing data. Initiatives such as these can also help foster data sharing, but it will take time and effort to find agreement about this protocol between organisations and implement it in practice.

3.3.4 Changing society and culture

A lot of the respondents also thought that in order for data sharing to become common practice, a more encompassing change is needed in society and culture. Under this theme we ordered all suggestions of use case leaders to do activities and projects in order to allow stakeholders to become acquainted with data exchanges, and slowly get used to it and build up a data-based culture in society. In the following we will explain why interviewees think a more open data culture is needed, and why open data bases, like data libraries, more collaborative projects and time to adapt helps to realise it.

Open data bases or data libraries

The suggestion to realise a data-based culture, where data are shared more openly, came forward recurrently during the interviews. One of the ways to foster such a culture, would be by making more data

publicly available. An open database, like a data library, with standard ways of exchanging data, could allow all stakeholders to interact with data, which could facilitate more frequent data interaction and exchange and therewith normalise it as being part of the social world, which would increase its acceptance.

> "To include for example cadaster data in an open database because some data is still available, but some data is not included in the open database. I believe all the data that is used by the public, should be included in this kind of database." – Vegetable trial

One respondent explained that many people are nowadays used to the collection of their personal data on websites and social media etc., but this is different when it comes to sharing business data. When business data will also become available on databases, then this will contribute to making it more 'normal' to share these data and resistance to sharing data can decrease. Having these data available and accessible for everyone on databases could, for example, convince farmers that it is not as risky to share data as they think it is.

Creating collaborative projects

Another way to foster a culture of data sharing mentioned by interviewees is to increase the number of collaborative projects. In these projects, actors are engaged in collaborations, which helps them to get to know each other, rely on each other and this eventually increases trust between them and this is the basis for the sharing of data.

> "I think that as a support from large third parties, supply chain projects can be created, collaborative projects. (...) Maybe investing some money into this, into real collaborative projects in the chain." – Fruit trial

Large projects in which collaboration is fostered can help bring about technological innovation but use case leaders also consider it valuable for social reasons: these projects also allow for social experiments around data sharing, which can eventually contribute to realising a culture of trust in data sharing. Companies, research institutes and other actors who usually do not share data, will start to share data in project teams. This helps to foster trust and will help to make data exchange between different actors in the supply chain common, possibly eventually causing a shift in society and culture. Funding more projects like IoF2020 could, according to some interviewees, therefore help foster data sharing.

Giving the sector time to adapt

Some interviewees called for patience. They thought that the sector needs time to understand and grow familiar with data sharing. New technologies generally need time to become accepted and adopted by users: users need to get to know the technologies, experiment with them, see the advantages and eventually adapt their business to them. Respondents indicated that some farms use little digital technologies; sometimes data are still collected manually, which makes the transition toward digital farming and data sharing more difficult. Furthermore, time could be needed for other reasons, such as the introduction of new policies regarding data sharing.

> "The management system of the companies is not so digital. That also does not help with the data sharing. Right now, most breeders [in Spain, HA], use manual records. Manual records are

difficult, because you need to have this for administration. With time this is going to happen." – Meat trial

4. DISCUSSION

At the end of this study, we can conclude that when interviewees from use cases in IoF2020 reflect about data sharing, they primarily understand it as a question pertaining to the data sharing of farmers and growers. In almost all use cases, farmers were mentioned as senders and/or receivers of data. In total, the number of data flows sent by farmers are larger compared to the number of data flows sent by other actors. Other actors frequently involved in exchanging data (sending and receiving) in all use cases are tech providers (companies), commercial cooperatives, producers, processors and research institutes (commercial as well as public). While universities are sometimes involved in use cases, other public institutes, such as policy makers/ministries or controlling bodies of the government, are only incidentally participating in the data sharing network. Furthermore, societal organisations like NGO's are rarely involved. Besides this, most data only flow within use cases. Use cases rarely involve external partners, except 'external' farms, who are not paid from the funds of the use case and are therefore not considered internal partners. While most use cases do have ideas to share data beyond the partners in their use case in the future, not many of them are doing this yet. This shows that data is now mainly shared to develop the IoT solution or the businesses of the participants in the use cases. Since data are not often shared with policy or societal organisations, realising broader, societal goals or fostering policy development is not the most important goal of data sharing, nor do use cases see it as an important goal to share data in the future.

Summarizing these results, we can say that use case leaders see a lot of benefit in data sharing for, in particular, farmers and growers. The main benefits are (1) that it enhances knowledge, which allows to tailor farming activities to the needs of the crop or animal, which improves the quality and quantity of the products; (2) it helps to optimize food production processes, which means that they become more efficient, cheaper and collaboration in the value chain becomes more fluid, and (3) data sharing helps to save time and realize more revenues for farmers. Obstacles to data sharing that use case leaders brought forward include (a) lack of information/knowledge of farmers and growers about the benefits that data sharing can offer them, (b) unclarity about the financial benefits that it brings (and uncertainty to do investments now, when benefits are expected at a later point in time), (c) lack of technological standardisation and (d) legislation and regulation-issues, which include existing legislation which obstructs data sharing as well as lacking legislation, for example when it comes to settling questions about who is the data owner and what rights belong to data owners.

Although use case leaders have experience in different farming sectors, they bring forward similar benefits and obstacles when it comes to data sharing for farmers and growers. Unsurprisingly, the solutions that use case leaders mentioned most frequently focused on ways to overcome these obstacles, such as (i) informing and educating farmers about the added value of data sharing, (ii) providing incentives to get them to share data, (iii) change and/or add new legislation, (iv) realise technological standardization and

(v) foster a socio-cultural transition by offering subsidies for collaborative projects, realise open data-bases (or data libraries), or simply by giving farmers and growers time to learn about the technologies, experiment with them and adapt their farm to include them in their daily production routines.

These results are perhaps unsurprising, as many articles have reported similar results in relation to the slow adoption and acceptance of smart farming technologies. These studies point out, for example, that farming is a traditional sector and that therefore innovations may take longer to get accepted and adopted, especially among older farmers who have little digital skills. In addition, the same studies report that the benefits of using digital farming technologies are often not so clear to farmers, or farmers don't have enough information on how to adapt current production processes to the new technologies (Paustian et al., 2017; Lencsés et al., 2014; Van der Wal., 2017; Barnes et al., 2019; Barnes et al., 2018). Other studies reveal acceptance problems, such as lack of trust in the technology or in the sharing of data with tech developers that is a prerequisite for the well-functioning of these technologies, or they have concerns about insufficiently developed institutional settings, including regulation and legislation, that govern data sharing and mitigate the detrimental effects of the evolving unequal power relationships between actors with and without access to data in the agri-food sector (Regan, 2019; Van der Burg et al., 2019).

This overlap between findings in our interviews and findings stemming from the literature could be seen as an affirmation of the truth of the findings. However, it seems to us that this conclusion would be too quick and too easy. During the interviews, the use case leaders rarely talked about their own role as contributors and users of the data sharing network. For this study we most often interviewed only one participant of the use case, the coordinator, who was often (but not always) a tech developer. Hereby we assumed that this person was able to represent the opinions of the entire use case. But, of course, it is likely that other participants in the use case (for example, other types of actors, such as farmers) would have another story to tell about the added value of data sharing as well as the obstacles encountered for that and the solutions offered (see for example D7.4 for perspectives on data sharing of farmers, Van der Burg et al. 2020b).

This also points to a second consideration about the results. Our interviewees primarily talked about data sharing in relation to farmers who feel hesitant or reluctant to share data, but they rarely spoke about their own obstacles to share data with others. This was surprising to us, as the overview they helped us to provide over their current data sharing activities show that they themselves rarely shared data beyond the limitations of their own use case. This suggests that participants in the use cases themselves also experience obstacles toward sharing data with outsiders to the use case and, in turn, also experienced obstacles in getting other types of actors (other than farmers and growers) to share data with them. From personal conversations with use case participants, we know that use cases sometimes tried to obtain data from companies outside of the use case, but oftentimes failed to get it. Also, in the focus groups about data sharing performed in WP7 of IoF2020 we encountered tech-developers who openly admitted finding it difficult to share data with other tech companies, as this could ruin their own business model which, as they explained, is based on their access to a unique data collection, which other tech companies do not have (see D7.4, Van der Burg et al. 2020b).

This suggests that there is a more complex story to tell about data sharing. Not only farmers and growers feel hesitant (or reluctant) to share data, but other businesses, including the tech developers, are often not eager to do that either. The use case coordinators that we talked to are often (but not always) commercial tech developers and as such they depend on access to datasets that their competitors do not have access to. Given this background, it is understandable that when they are asked about data sharing, they first and foremost focus on the problem that makes their business vulnerable: which is, getting farmers and growers to share their data. They may however have a huge interest to get farmers to share their data, but not a large interest to share data themselves with other partners outside of the use case, especially not with other tech companies.

This is important to take into account when looking at the solutions that use case leaders provide to overcome obstacles for data sharing and which we noted in the recommendations below. While some of these solutions try to foster open data flows, which allows to use data for research, innovation and to foster the market flow of data, it is important to take into account that sharing data is not always good for business. This probably sets limitations to the realisation of data sharing spaces which need careful consideration.

5. RECOMMENDATIONS

Based on the results of the interviews with 33 use cases, we come to the following recommendations for actions that various actors can take to foster data sharing.

For providers of data platforms:

- Education and clear communication of the added value as well as the risks of sharing farm data on data platforms:
    - Show on the platform what the actual benefit is for the farmer when the data is shared with for example a company (will they get money, information, what are estimations for the extra profits they can expect?)
    - Provide clear and accessible information about what the data user will do with the data and (possibly also) what profits he/she will harvest from that and give something back to the farmer in exchange for those profits
    - Provide clear information about the risks related to data sharing and how the risks are mitigated
    - Work toward making data FAIR, in order to be able to connect to data from other platforms

For governments:

- Make some data sharing mandatory, for example with respect to showing compliance with the law, or for the fostering of public goals, such as food safety or the protection of natural resources and the environment
- Create incentives to share data, for example by offering subsidies or tax-advantages when actors decide to share data

- Assess present regulation which protects data and look for possibilities to (a) change regulation where it imposes unnecessary limitations to data sharing, and (b) create new regulation to clarify the rights of data sharing partners, such as for example data ownership rights which point out who is entitled to decide about and benefit from what data
- Support new projects which foster collaboration between actors in the farm data sharing network, which allows to experiment with the technology, as well as with the collaboration with the data-based social network around it
- Foster standardization of technology by offering subsidies and demanding to make data FAIR
- Foster the development of databases (as 'libraries') which are accessible to all actors and which allow to experiment with data and get to know what can be done with them, or learned from them

For farmer cooperatives:

- Educate and communicate clearly about the benefits of data sharing, as well as the risks
- Foster collaboration in projects which allow farmers to become acquainted with digital farming technology and experiment with the technology, as well as with the social collaboration around it
- Think about preconditions that need to be satisfied before sharing farm data, which help the farmer to make sensible decisions about when to share data, for what purposes and with whom
- Act as a true representative of farmers in the negotiation with other stakeholders in the data sharing network, in order to make sure that farmers can harvest benefits of digital farming while protecting them against the harms it may bring them
- Empower farmers by giving them digital education

For tech companies:

- Take responsibility to give something valuable back to the farmer or other actors in exchange for their data.
- Explain to the farmer what they are going to do with the data and why and ask for consent
- Participate in collaborative projects like IoF to become acquainted with and foster data sharing collaborations, and in that way foster a data sharing culture
- Share data for public purposes, such as food safety or the environment
- Make data FAIR
- (And perhaps) Think about preconditions that need to be satisfied to share data with other data sharing partners, without harming one's own business model

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Appendix A – Interview guide

1. With what types of actors is data currently shared in your USE CASE?
2. What is the direction of each flow of data sharing (from the USE CASE to the actor or vice versa)?
3. What type of data do you share with these actors?
4. What are the main reasons for your USE CASE to share data with these actors?
5. With what types of (other) actors would your USE CASE like to share data in the **future**?
6. What type of data would you like to share with the actors?
7. What are the main reasons for your USE CASE want to share data with these other actors in the future?
8. What holds you back? What are the main reasons why you do not share data with these particular actors yet?
9. Do you experience or expect particular obstacles to share data with these partners?
10. What does your USE CASE need to start sharing data with more actors?
11. What do you think should be done to foster data sharing?
12. Who should take action to foster data sharing?
13. One of the initiatives intended to overcome obstacles to data sharing is the creation of extended platforms such as DjustConnect and JoinData. Are you familiar with these platforms?
    a. If yes, how would you evaluate the contribution that these platforms offer to data sharing?

Appendix B – Glossary list of actors and list of kinds of data

As mentioned in the method chapter of this report, we used the EU code of conduct on agricultural data sharing by contractual agreement by COPA COGEGA et al. (2018) to shape the list with types of data. The definitions we used are based on this code of conduct, the Multilingual Thesaurus of the FAO (2020) and the and GSI (2020). After developing a draft list of different types of data, we looked into different progress reports of use cases to see what we missed and finalized the list in agreement with WP leaders.

Types of data	**Description**
(IoT) device data	Any data related to (IoT) devices e.g. status, battery and connectivity level etc.
Agricultural product data	Any data related to the result of agricultural production in their original state or processed enough to be prepared for marketing e.g. milk quality, wine characteristics
Agri-supply data (inputs)	Any data related to the nature, composition and use of inputs such as fertilizers, feedstuffs, plant protection products etc.
Crop and seeds data	Any data related to individual plants or group of plants e.g. plant chemical and nutritional composition, biomass, leaves wetness, health, yield, seed density etc.
Estate data	Any data related to a large area of land in the country which is owned by a family or an organization and is often used for growing crops or raising animals e.g. building characteristics (size, maintenance)
Farm equipment data	Any data related to equipment (tractors, implement etc.) e.g. settings, speed, tyre pressure, parameters etc.
Field data	Any data related to the fields e.g. boundaries, location, crop rotation etc.
Financial data	Any data related to the financial health of a business e.g. profits, losses, costs, transactions, investments, credits etc.
Indoor environment data	Any data related to the weather and air quality inside a building or a container e.g. CO^2 level in a shed, temperature of a wine barrel, dust etc.
Labor data	Any data related to the labour e.g. number of workers, working time etc.
Livestock consumption data	Any data related to individual animals or herds consumption and patterns e.g. feed and water amount etc.
Livestock health data	Any data related to individual animals or herds health e.g. heart rate, disease, mortality etc.
Livestock physical and reproductive characteristics data	Any data related to individual animals or herds physical and reproductive characteristics e.g. weight, growth, fertility, genetics etc.
Outdoor weather data	Any data related to the state of the atmosphere e.g. temperature, wind speed, humidity, solar radiation etc.
Soil data	Any data related to the soil e.g. soil composition, property, conductivity etc.
Transport Items data	Any data related to items that are used for moving or transporting goods. They are usually returnable e.g. location of smart trays, temperature etc.
Water data	Any data related the water either for the irrigation of the fields or for the animal consumption e.g. flow, pressure, water quality etc.

To define the different types of actors, we used literature like Santoro (2000), Kramar et al. (2013) and Curry (2016). Besides that, rapports and non-scientific articles as Bhasin (2018) and Osterwalder and Pigneur (2009) were used to clarify the definitions.

Business	**Business**	**Definition**
	Farmer	A person who manages or owns an agricultural farm of any kind.
	Producer	Any company or person that creates economic value or produces goods and services (excluding tech providers).
	Tech provider	A company that provides, produces and/or supplies technological equipment of any kind. This can be software, hardware or telecom providers of any kind of technological products.
	Advisor	A person or business that provides advise in different kinds. This could be in the role of an agronomist giving (general) advise to a farmer, or a nutritionist providing the farmer of advice regarding the feed of the animals.
	Processor	A person or business that adds significant value by transforming the commodity into more complex, and, possibly, finished products, e.g. combining of commodity products, turn them into an ingredient for further processing or use by a consumer as an ingredient.
	Veterinarian	A person that treats diseased or injured non-human animals
	Supplier	A person or business that provides a product or service to another entity. Acts as an intermediary between the manufacturer and retailer.
	Logistics	A person or business that analyses and models division-of-labor economic systems as time-based and location-based flows of agricultural objects (above all goods and people) in agricultural networks, supplying recommendations for action on the design and implementation of these agricultural networks.
	Distributor	An independent person or legal entity that sells goods locally on behalf of a principal. Increase the visibility and sales of the product.
	Retailer	A person or business that sells goods directly to the end consumer in relatively small quantities for use or consumption rather than for resale.
	Wholesaler	Person or business that buys large quantities of products directly from distributors.
	Cooperative	A (commercial) association of persons or organisations united to meet similar needs or aspirations through an enterprise

	Certifiers / auditor	A person or business that supervises a particular industry or business activity and/or checks the quality of (in this case) agricultural products.
	Insurance company	A business, which may be for-profit, non-profit or government-owned, that sells the promise to pay for certain expenses in exchange for a regular fee, called a premium.
	Industrial research	Research centers encourage diverse collaborative activities, embody a formalized structure and have leadership whose explicit mission is to transfer knowledge specifically for advancing new technologies.
	University and research centre	University or university department of any kind and independent non-profit research institutes
	Ministry/municipality/policy maker	Any department of governmental organisations (at international, national, regional or local level) that are involved in the development and implementation of policies.
	Regulator/controlling body of government	Part of the government that is responsible for the controlling of compliance with the law.
	Consumers	The end-user of the product.
Societal organisations	NGO	Any kind of non-governmental organizations
	Farmers' organisation	A not for profit farmers' cooperative

Appendix C – Tables with data sharing flows

In this appendix we provide tables, which provide an overview over data flows in each use case. Data that is noted in orange in the tables represent anticipated or wanted data flows in the future, which are not yet part of the use case.

TRIAL 1 Arable farming

UC 1.1			Data receiver				
			Business		**Public**		**Societal organisations**
			Farm	*Tech provider*	*University and Research*	*Ministry/ municipality/policy maker*	
Data sender	**Business**	*Farm*		- Crops and seed data - Soil data	- Crops and seed data - Soil data		
		Demonstration farm	- Crops and seed data - Soil data	- Crops and seed data - Soil data	- Crops and seed data - Soil data		
		Tech provider	- Crops and seed data - Soil data				
	Public	*University and Research*		- Crops and seed data - Soil data		- Crops and seed data - Soil data	
	Societal organisations						

UC 1.2			Data receiver					
			Business				**Public**	**Societal organisations**
			Farm	*Processor*	*Cooperative*	*Industrial research*	*University and research*	
Data sender	**Business**	*Farm*			- Agri-supply data - Crops and seed data			
		Tech provider 1				IoT device data		
		Tech provider 2			Outdoor weather data			
		Cooperative				- Agri-supply data - Crops and seeds data - Outdoor weather data		
		Industrial research	- Agri-supply data - Crops and seeds data - Outdoor weather data	- Agri-supply data - Crops and seeds data - Outdoor weather data	- Agri-supply data - Crops and seeds data - Outdoor weather data		- Agri-supply data - Crops and seeds data - Outdoor weather data	
	Public							
	Societal organisations							

UC 1.3			Data receiver				
			Business			**Public**	**Societal organisations**
			Farm	*Tech provider*	*Certifier / auditor*	*University and Research*	
Data sender	**Business**	*Farm*			- Crops and seed data - Soil data - Field data		
		Producer (machine)			- Crops and seed data		
		Tech provider			Outdoor weather data	Crop and seed data	
		Certifier / auditor	- Crops and seed data - Soil data	- Crops and seed data - Field data			
	Public	*Ministry*			- Crops and seeds data - Field data		
	Societal organisations						

UC 1.4			Data receiver				
			Business		**Public**		**Societal organisations**
			Producer (machine)	*Tech provider*	*Ministry/municipality/policy maker*	*University and Research*	
Data sender	**Business**	*Producer (machine)*		Farm equipment data			
		Tech provider	Farm equipment data		Farm equipment data	Farm equipment data	
	Public						
	Societal organisations						

UC 1.5			Data receiver						
			Business					**Public**	**Societal organisations**
			Farm	*Producer (machine)*	*Processor*	*Retailer*	*Distributor*		
Data sender	**Business**	*Farm*		Crops and seed data					
		Producer (machine)	Crops and seed data		Crops and seed data	Crops and seed data	Crops and seed data		
	Public								
	Societal organisations								

UC 1.6			Data receiver						
			Business				**Public**	**Societal organisations**	**Other UC***
			Farm	*Producer (fertilizers)*	*Tech provider*	*Industrial research*			UC 4.5
Data sender	**Business**	*Farm*			- Crops and seed data Soil data - Outdoor weather data - Agri-supply data (inputs)				
		Tech provider	- Crops and seed data Soil data - Outdoor weather data - Agri-supply data (inputs)	- Crops and seed data - Soil data - Outdoor weather data - Agri-supply data (inputs)		- Crops and seed data Soil data - Outdoor weather data - Agri-supply data (inputs)			- Outdoor weather data - (IoT) device data
	Public								
	Societal organisations								

*Unknown which type of actors within that use case

UC 1.7			Data receiver						
			Business					**Public**	**Societal organisations**
			Farm	*Producer (trailers)*	*Tech provider*	*Processor (feed)*	*Logistics*		
Data sender	**Businesses**	*Farm*		- Farm equipment data - Agri-supply data (inputs)					
		Producer (trailers)	- Agri-supply data (inputs) - Transport Items data		- Agri-supply data (inputs) - Transport items data	- Transport items data/delivery data	- Transport items data/delivery data		
		Processor (feed)		- Agri-supply data (inputs) - Transport Items data					
		Logistics		Transport Items data					
	Public								
	Societal organisations								

UC 1.8			Data receiver							
			Business						**Public**	**Societal organisations**
			Farm	*Tech provider 1*	*Tech provider 2*	*Processor*	*Certifier / auditor*	*Industrial research*	*University and research*	
Data sender	**Businesses**	*Farm*		- Soil data - Crops and seed data						
		Tech provider 1	- Soil data - Crops and seed data		- Soil data - Crops and seed data - Outdoor weather data	- Soil data - Crops and seed data	- Soil data - Crops and seed data	- Soil data - Crops and seed data	- Soil data - Crops and seed data	
	Public									
	Societal organisations									

UC 1.9			Data receiver						
			Business					**Public**	**Societal organisations**
			Farm	*Tech provider 1*	*Tech provider 3*	*Advisor*	*Cooperative*		
Data sender	**Business**	*Farm*		Crops and seed data					
		Tech provider 1	Crops and seed data		Crops and seed data	Crops and seed data	Crops and seed data		
		Tech provider 2	Crops and seed data	Crops and seed data					
		Advisor	Crops and seed data						
	Public	*University and Research*			Crops and seed data				
	Societal organisations								

UC 2.1			Data receiver							
			Business				**Public**			**Societal organisations**
			Farm	*Tech providers*	*Certifiers / auditors*	*Insurance company*	*University and research*	*Regulator / controlling body of government*	*Consumer*	
Data sender	**Business**	*Farm*		Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	
		Tech provider	Livestock physical and reproductive characteristics data							
	Public									
	Societal organisations									

UC 2.2			Data receiver								
			Business							**Public**	**Societal organisation**
			Farm	*Tech provider 1*	*Tech provider 2*	*Advisor (nutritionist)*	*Processor (feed)*	*Veterinarian*	*Certifier / auditor*		
Data sender	**Business**	*Farm*		Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data		
		Tech provider 1	Livestock physical and reproductive characteristics data								
	Public										
	Societal organisations										

UC 2.3			Data receiver		
			Business	**Public**	**Societal organisations**
			Farm	*University and Research*	
Data sender	**Business**	*Farm*		- Livestock consumption data - Livestock physical and reproductive characteristics data - Outdoor weather data	
	Public	*University and Research*	- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data		
	Societal organisations				

UC 2.4			Data receiver				
			Business			**Public**	**Societal organisations**
			Processor	*Wholesaler*	*Certifier / auditor*		
Data sender	**Business**	*Processor*			Agricultural product data		
		Certifier / auditor	Agricultural product data	Agricultural product data			
	Public						
	Societal organisations						

UC 2.5			Data receiver								
			Business						**Public**		**Societal organisations**
			Farm	*Tech provider 1*	*Tech provider 2*	*Processor*	*Veterinarian*	*Retailer*	*University and Research*	*Consumer*	
Data sender	**Business**	*Farm*		Livestock physical and reproductive characteristics data	Livestock physical and reproductive characteristics data				Livestock physical and reproductive characteristics data		
	Public	*University and Research*	Livestock health data	Livestock health data	Livestock health data	Livestock health data	Livestock health data	Livestock health data		Livestock health data	
	Societal organisations										

UC 2.6			Data receiver				
			Business	**Public**			**Societal organisations**
			Advisor	*University and Research 1*	*University and Research 2*	*University and Research 3*	*NGO*
Data sender	**Business**	*Farm*	- Livestock consumption data - Agricultural product data	- Livestock consumption data - Agricultural product data	- Livestock consumption data - Agricultural product data	- Livestock consumption data - Agricultural product data	- Livestock consumption data - Agricultural product data
	Public						
	Societal organisations						

UC 2.7			Data receiver					
			Business				**Public**	**Societal organisations**
			Farm	*Producer (pharmaceutics)*	*Tech provider 1*	*Tech provider 2*		
Data sender	**Business**	*Farm*			- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data	- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data		
		Tech provider 1	- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data	- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data		- Livestock consumption data - Livestock physical and reproductive characteristics data - Livestock health data		
	Public							
	Societal organisations							

UC 3.1			Data receiver							
			Business				**Public**			**Societal organisations**
			Farm	*Tech provider*	*Advisor (consultant)*	*Cooperative*	*University and Research 1*	*University and Research 2*	*Consumer*	
Data sender	**Business**	*Farm*		- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)	
		Tech provider	- Soil data - Crops and seed data - Outdoor weather data - Agri-supply data (inputs)							
	Public									
	Societal organisations									

UC 3.2			Data receiver				
			Business			**Public**	**Societal organisations**
			Farm	*Tech provider*	*Industrial research*		
Data sender	**Business**	*Farm*		Outdoor weather data	- Outdoor weather data - Indoor environment data		
		Tech provider	Outdoor weather data				
	Public						
	Societal organisations						

UC 3.3			Data receiver								
			Business						**Public**		**Societal organisations**
			Farm	*Tech provider 1*	*Tech provider 2*	*Advisor (agronomist)*	*Cooperative 1 (Greek)*	*Cooperative 2 (Spanish)*	*University and Research*	*Regulator / controlling body of government*	
Data sender	**Business**	*Farm*				- Outdoor weather data - Water data	- Outdoor weather data - Water data	- Outdoor weather data - Water data		- Agri-supply data (inputs)	
		Cooperative 1 (Greek)	- Outdoor weather data - Water data	- Outdoor weather data - Water data	- Outdoor weather data - Water data				- Outdoor weather data - Water data		
		Cooperative 2 (Spanish)	- Outdoor weather data - Water data	- Outdoor weather data - Water data	- Outdoor weather data - Water data				- Outdoor weather data - Water data		
	Public										
	Societal organisations										

UC 3.4			Data receiver						
			Business					**Public**	**Societal organisations**
			Farm	*Tech provider*	*Processor*	*Distributor*	*Retailer*	*Regulator / controlling body of government*	
Data sender	**Business**	*Logistics*	- Transport items data - Indoor environment data	Transport items data	- Transport items data - Indoor environment data	- Transport items data - Indoor environment data	- Transport items data - Indoor environment data	- Transport items data - Indoor environment data	
	Public								
	Societal organisations								

UC 3.5			Data receiver			
			Business		**Public**	**Societal organisations**
			Tech provider	*Insurance company*		
Data sender	**Business**	*Farm*	Crops and seed data	Crops and seed data		
	Public organisation					
	Societal organisations					

UC 3.6			Data receiver									
			Business								**Public**	**Societal**
			Producer	*Processor*	*Supplier*	*Logistics*	*Distributor*	*Retailer*	*Wholesaler*	*Insurance company*	*Consumer*	
Data sender	**Business**	*Tech provider*	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	Indoor environment data	
	Public organisation											
	Societal organisations											

UC 4.1			Data receiver				
			Business		**Public**		**Societal organisations**
			Farm	*Tech provider*	*University and Research 1*	*University and research 2*	
Data sender	**Business**	*Farm*		Crops and seed data			
		Tech provider	Crops and seed data		Crops and seed data	Crops and seed data	
	Public						
	Societal organisations						

UC 4.2			Data receiver									
			Business							**Public**		**Societal organisations**
			Farm	*Processor*	*Logistics*	*Distributor*	*Retailer*	*Wholesaler*	*Cooperative*	*University and Research*	*Consumer*	
Data sender	**Business**	*Farm*							- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data		
		Tech provider 1								(IoT) device data		
		Tech provider 2								Outdoor weather data		
		Cooperative		- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data			- Agri-supply data (inputs) - Crops and seed data	

	Public	*University and Research*	- Agri-supply data (inputs) - Crops and seed data - Outdoor weather data									
	Societal organi-sations											

UC 4.3			Data receiver					
			Business				**Public**	**Societal organisations**
			Farmer	*Producer 1*	*Producer 2*	*Advisor (consultant)*	*University and Research*	
Data sender	**Business**	*Farm*		- Crops and seed data - Field data	- Crops and seed data - Field data	- Crops and seed data - Field data	- Crops and seed data - Field data	
	Public	*University and Research*	- Crops and seed data - Field data					
	Societal organisations							

UC 4.4			Data receiver		
			Business	**Public**	**Societal organisations**
			Certifier / auditor	*Regulator/ controlling body of government*	
Data sender	**Business**	*Farm*	Crops and seed data		
		Certifier / auditor		Crops and seed data	
	Public				
	Societal organisations				

UC 4.5			Data receiver							
			Business					**Public**		**Societal organisations**
			Farm	*Tech provider*	*Advisor*	*Retailer*	*Wholesaler*	*University and Research*	*Consumer*	
Data sender	**Business**	*Farm*		Outdoor weather data	Outdoor weather data	Outdoor weather data	Outdoor weather data	Outdoor weather data	- Outdoor weather data - Agricultural product data	
		Tech provider	Outdoor weather data							
	Public									
	Societal organisations									

UC 5.1			Data receiver						
			Business				**Public**		**Societal**
			Farm	*Tech provider*	*Veterinarian*	*Cooperative*	*University and research 1*	*University and research 3*	
Data sender	**Business**	*Farm*		- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	
		Processor - slaughterhouse		- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data			- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data - Agricultural product data	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data	

				- Agricultural product data				- Agricultural product data	
	Public	*University and research 2*	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data						
		University and research 3	- Livestock consumption data - Indoor environment data - Livestock physical and reproductive characteristics data						
	Societal organisations								

UC 5.2			Data receiver							
			Business						**Public**	**Societal organisation**
			Farm	*Tech provider 1*	*Tech provider 2*	*Processor*	*Logistics*	*Cooperative*		
Data sender	**Business**	*Farm*		- Livestock consumption data - Indoor environment data						
		Tech provider 1			- Indoor environment data - Livestock consumption data - Transport Items data			- Indoor environment data - Livestock consumption data - Transport Items data		
		Logistics		Transport items data						
		Cooperative	- Indoor environment data - Livestock consumption data - Transport Items data			- Indoor environment data - Livestock consumption data - Transport Items data	- Indoor environment data - Livestock consumption data - Transport Items data			
	Public									
	Societal organisations									

UC 5.3			Data receiver				
			Business			**Public**	**Societal organisations**
			Farm	*Processor – slaughterhouse*	*Certifier / auditors*		
Data sender	**Business**	*Farm*		- Livestock health data - Livestock physical and reproductive characteristics data	- Livestock health data - Livestock physical and reproductive characteristics data		
		Processor - slaughterhouse	- Livestock health data - Livestock physical and reproductive characteristics data		- Livestock health data - Livestock physical and reproductive characteristics data		
	Public						
	Societal organisations						

UC 5.4			Data receiver			
			Business		**Public**	**Societal organisations**
			Producer	*Processor*	*Consumer*	
Data sender	**Business**	*Farm*	- Livestock health data - Livestock physical and reproductive characteristics data	- Livestock health data - Livestock physical and reproductive characteristics data	Livestock health data	
	Public					
	Societal organisations					

UC 5.5			Data receiver							
			Business						**Public**	**Societal organisations**
			Farm	*Producer - Feed*	*Tech provider 1*	*Tech provider 2*	*Supplier – advice*	*Cooperative*	*University and Research*	
Data sender	**Business**	*Farm*			- Indoor environment data - Livestock consumption data					
		Tech provider 1	- Indoor environment data - Livestock consumption data	- Indoor environment data - Livestock consumption data		- Indoor environment data - Livestock consumption data	- Indoor environment data - Livestock consumption data	- Indoor environment data - Livestock consumption data	- Indoor environment data - Livestock consumption data	
	Public									
	Societal organisations									

UC 5.6			Data receiver					
			Business				**Public**	**Societal organisations**
			Farm	*Tech provider*	*Veterinarian*	*Industrial research*	*University and Research*	
Data sender	**Business**	*Farm*		- Livestock health data - Indoor environment data	- Livestock health data - Indoor environment data	- Livestock health data - Indoor environment data	- Livestock health data - Indoor environment data	
		Industrial research	- Livestock health data - Indoor environment data					
	Public							
	Societal organisations							