D4.6: VALIDATION OF USER ACCEPTABILITY IN IOF2020 USE CASES

WP 4

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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.

Nineteen 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 expected 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.

EXECUTIVE SUMMARY

This deliverable presents user acceptance testing services delivered by WP4 Business Support to IoF2020 use cases to improve user acceptance of their solutions. By involving the end users as much as possible during the Minimal Viable Product (MPV) cycle the opportunities for the solution to reach the market are increased, stimulating the overall uptake of IoT solutions in agri-food.

When users are positive about using a technical solution, the chances of them actually using the solution increase. Usefulness, ease of use, performance expectancy and knowledge transfer are expected to influence this intention of a farmer or other end user to use the solution. It is also important that the end user perceives the economic value of the solution and that the solution actually works on the farm. These two factors in the surroundings of the end user or in the context of the solution should also be taken into account to address user acceptance. For example, if the solution works well, is it easy to use? Is it too expensive or is the data from the sensor not being transmitted to the base station in real time? For a farmer to accept technology, the importance of the experience of other farmers and having confidence in the solution play a role.

Within IoF2200, supporting use cases in user acceptance testing and processing data from these tests provided valuable insights into the use case solutions. Data from the survey with 59 respondents (farms and companies) and 9 use case end users' interviews were analysed. The conversations with end users provided additional insights and were quite helpful in understanding user acceptance.

The results are presented in this report to fully understand the elements of user acceptance such as usefulness, ease of use, and perceived economic value. It reveals the key experiences, feedback and issues in using smart farming solutions in the context of IoF2020.

Generally, the end users perceive the IoT solution at the farm or company as useful, and solution offer benefits in comparison with current farming practices. Reduced working time is one of the most important benefits. Next benefit is ability to control the work precisely and increase the speed and efficiency of accomplishing tasks .

Although in some cases special ICT expertise is needed, the solutions are perceived as easy to understand and easy to use. Importantly, after receiving trainings in using IoT, end users indicate that the installation of the IoT solution and the design is easy to work with.

End users expect productivity and profit increase, and reduction of cost as a result of IoT use. Most of the interviewed end users could even measure an increase of yield and better quality after using IoT. Being able to take better management decisions based on real-time data allows for quick reactions to changing circumstances. These are the ways in which the end user perceives economical value.

Experience of other farmers with digital solutions is an important source of information for farmers. Most end users are confident about using the digital solution and these users also responded to actually using the solution. Being confident about using the solution is also related to the solution being easy to understand, providing more accurate decision making and clear benefits.

Facilitating conditions also impact the intention to use a solution. For the IoF2020 use cases the most crucial conditions are: the connection between data receiver and data transformer, presence of internet connection and availability of WiFi, GSM and mobile network coverage and guarantees of security. Technical issues highlighted by the end user are battery life of hardware, robustness of the hardware and flexible telecommunication plans for end users.

The majority of the respondents have actually applied and currently use the IoT solutions. Some test the solution planning to apply it within a year, or express their interest. A few use cases wait for harvesting seasons to provide an interoperability solution to exchange data, and one use case does not have an actual user interface to test. Final IoF2020 reporting will report on the last few use cases that are in the middle of final development and testing.

In general, usefulness and ease of use are evident when adopting IoT solutions in the agri-food sector and usually lead to actual use of the product. They are also related to the confidence an end user has in using IoT solution. Therefore, we recommend IoF2020 use cases, and similar start-up initiatives to consider usefulness and ease of use when developing and validating their product by the end users, and work towards end user confidence.

Age of the end user appeared to be important too. Unfortunately this study does not provide a hard quantitative evidence of correlation between the age of the farmer and the actual usage of IoT mostly due to lack of sufficient responses. However, the interview results reveal that relatively younger farmers with less conservative attitude adopt IoT easier than their experienced peers.

One of the most important findings is that due to varieties in IoT solutions in use cases and the maturity level of products and solutions, developing a one-fits-all tool for use acceptance testing is challenging if not impossible. Therefore, this report advises to use the suggested user acceptance tools cautiously and adjust/customize to the end user needs wherever needed.

This report recommends engaging younger farmers to showcase best practices as well as matching them with less experienced or older farmers during development to share knowledge. Other recommendations are to take language barriers into account, start early on with user acceptance testing. Insights into the use case characteristics that play a role in their business models are expected to be presented in Deliverable 4.5 *Overall lessons learned regarding business model* (to be finalized in March, 2021).

For policy makers, this report recommends efficient exploitation of enormous potential of digitalization and data driven operation in agri-food sector. In this digital transformation, policy should stimulate collaboration among chain partners for innovative solutions that contribute to sustainable solutions. Even farming, which is not famous in innovativeness and high tech adoption, will change radically to produce sustainably, taking successful examples that IoF2020 use cases demonstrate. For this change, the application of professional user acceptance testing in every research project that intends to bring products or solution to the market is key.

1 INTRODUCTION

The main goal of 'WP4: Business support' is to assess market readiness, define business models & prepare market entry. One of the most important activities to reach this goal is to validate user acceptance for use cases and identify acceptance criteria by end users to adjust the product/service already in development. The activity is entirely in line with the IoF2020 demand-driven methodology. User acceptance testing is meant to serve the development of the Minimum Viable Product (MVP) as a validation tool. User acceptance testing is crucial to collect feedback, values, preferences and needs of end users to be able to consider these factors in each cycle of MVP when developing the solution (*Figure 1*). Thus, user acceptance testing, as a crucial part of MVP helps overcome major barriers to acceptance of IoT technologies in European agriculture.

The objective of this deliverable is to inform IoF2020 stakeholders about the overall user acceptance of IoF2020 solutions by validating the research results gathered from surveys and interviews. The 33 IoF2020 use cases represent different agricultural sectors in several European countries. The characteristics of the use cases therefore vary considerably. Nevertheless, during the project, use cases were enabled to address any improvement feedback received from user acceptance testing, and further develop the IoT solutions. Use cases conducted the user acceptance testing themselves mainly using the tools provided by WP4 support team. Additionally, WP4 team has conducted quick feedback sessions and interviews to unlock broad and in-depth user acceptance feedback. By using various tools, we uncovered valuable insights, such as the most and the least important features of the solution and improvement opportunities as experienced by the end users. This report does not aim to validate the success of the use cases or the IoT solutions, but rather to present the success of user acceptance testing tools and shows how IoF2020 solutions are perceived by the end users, and how the testing results can be used to improve IoT products in agri-food.

The structure of this documents follows the research approach of literature review, quantitative data analysis based on questionnaire data and qualitative analysis using interview data. Section 2 describes user acceptance in the IoF2020 project including the theoretical framework. In section 3 the approach of user acceptance testing is described to understand which activities have led to the results presented in this document. The research results are presented in section 4 (questionnaire data) and section 5 (interview data). The concluding section presents overall findings, connecting them back to what was already found in the literature. The final section provides recommendations to IoF2020 use cases and similar IoT initiatives, to IoT focused (European) project stakeholders and policy makers.

2 USER ACCEPTANCE IN IOF2020

In the agri-food sector, external environment (e.g. market and weather fluctuation) is more variable and unpredictable than in any other sector; and therefore the need to reduce uncertainties in e.g. food quality and safety is more urgent (Verdouw, Sundmaeker, Tekinerdogan, Conzon, & Montanaro, 2019). IoT applications in agri-food allow monitoring, controlling, planning and optimization of processes in a virtual way in addition to relying on only physical observations. Agri-food supply chain partners can use IoT to build self-adaptive systems in which smart objects operate, decide and learn autonomously (Verdouw et al., 2019). The agri-food sector is expected to benefit from IoT in dealing with major sustainability challenges, such as food waste, variable harvest, unpredictable supply, food safety, and agri-food sustainability. Additionally, IoT solutions improve safety systems and support making informed decision, e.g. by providing warning systems in case of incidents, allowing re-considering decisions in case of unexpected change in external environments.

However, the IoT technologies have not yet achieved wide uptake and acceptance as one would expect. To achieve wider uptake and acceptance, technologies need to be properly embedded in the food chain and integrated with the business models of the chain actors. Many factors explain the slow uptake, such as lack of certain technical and technological quality, infrastructure, compatibility and interoperability standards, concern about safety, high costs and uncertainty about benefits and usability (Saenz, Elkmann, Gibaru, & Neto, 2018). Uptake and acceptance of technology can increase when the technology is better matched with user needs and user expectations, and capacities are better matched with what the technology offers (Broadbent, Stafford, & MacDonald, 2009). To realize acceptable IoT applications, end user's needs, values, concerns and capacities need to be considered.

The WP4 user acceptance team has initiated the user acceptance testing tools to support the 33 use cases engaged in the IoF2020 project. The objective is to understand the end users, consider their concerns, needs, values, receive feedback from them, integrate end user feedback in the tech development, and by doing so, improve the offered IoT services along the years. Though the Technology Readiness Level (TRL) may be different per use case, an overview of current end user acceptance can be provided. As part of the WP4 task "T4.3 - Product Support", the objective for the User Acceptance Testing (UAT) team is to support use cases in building successful, well-accepted solutions and to promote them to gather feedback from end-users in all stages of product development, including the very early stages.

This report aims to provide insight into two main questions:

Which user acceptance testing services support IoF2020 use cases to understand and improve user acceptance?

What are the key experiences, feedback and issues in using smart farming solutions at the start-up phase in the context of IoF2020?

Testing user acceptance is usually the final step of technology development where end users accept the final product. In IoF2020, however, user acceptance is important tool during all development stages to understand end users' experience. Questions, such as how end users experience working process with IoT products starting from the installation of sensors until the full functioning automated systems, what compatibility issues between systems are encountered are highly relevant. End user needs may change over time, therefore, IoF2020 methodology includes Lean practices to develop

products. A Minimal Viable Product (MVP) is gradually developed and should provide a minimal solution to the customer from the first version.

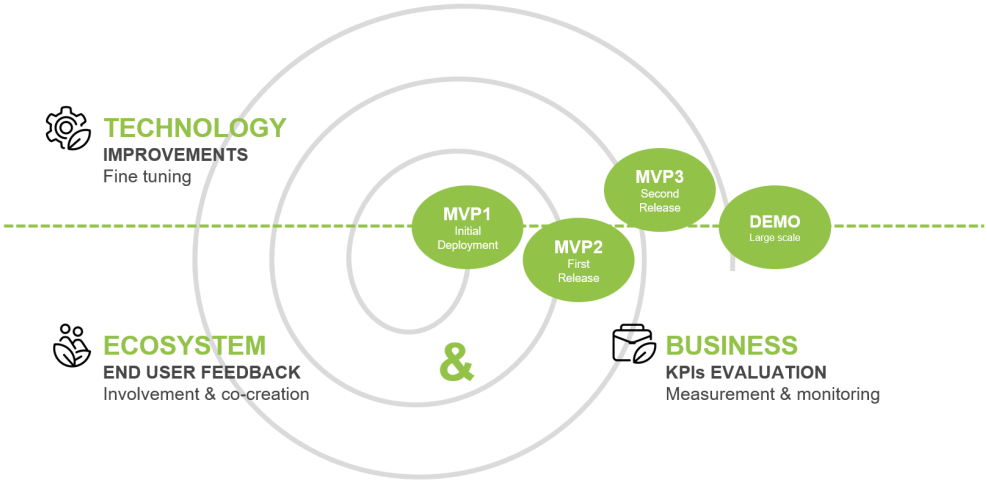


Figure 1: lean MVP approach in IoF2020

User feedback can be used to further improve the product as well as planning future MVP releases. User testing should be mostly about the product itself, for example, ease to use dashboard, and not necessarily the IoT Hardware, because this is not the product the user interacts with.

To assess user experience and receive relevant feedback, the team has based UAT activities on the technology acceptance model (TAM), and studied the recent developments of the model. According to TAM, the main factors for technology adoption are usefulness and ease of use. If the end users (e.g. farmers) believe the new technology will enhance their performance, they are more eager to apply technology in their daily practice (Davis, 1989, Flett et al., 2004). If end users believe that technology application is easy to use, their attitude toward IoT solutions will be positive and adoption will be more plausible (Davis, 1989, Rothensee, 2008). Eventually, users need to perceive positive economic value too (Adrian et al., 2005, Rothensee, 2008).

Technology innovation can be driven from a business or technology perspective. A new technology solution is aimed at end users, who are the driving force of user acceptance with respect to their needs, concerns and expectations. Key aspects to increase user acceptance at the project level and adoption at a larger scale are often hidden to the end user and impacted by system design, architecture and potential interoperability of technological and specifically IoT based distributed components. Generally and in IoF2020, data from end users are gathered through ‘user acceptance tests’ that focus on:

- Usefulness
- Usability / Ease of use
- Technology (including mobile connection)
- Cost-efficiency / economic value

Ethical aspects were not included in the UAT activities, because they are part of WP6. To fully engage all stakeholders in user acceptance testing, webinars and trial sessions have been organized and survey tooling has been offered to end users, led by the UAT team.

Stakeholders in the IoF2020 project that are directly using produced services and/or benefiting from outcomes are the end users. IoF2020 includes end users for the entire supply chain, from farm to the

plate. These can be farm equipment suppliers, food processing companies, transporters, retailers and consumer associations. The end users in IoF2020 use cases are categorized into two types of end users. These are (1) the dairy, meat, fruit, vegetable and arable farmers across trials and (2) the processing companies. For example, dairy processing companies from Use Case 2.4 can use an information platform to access quality assurance service of locally obtained milk and remote dairy composition analyses. Another example are potato farmers and the potato processing industry from Use Case 1.5 that aims to track potato produce back to the field regarding food security and quality, supporting buyers and processors while at the same time helping the farmers to identify problems and improve their yields in the following years.

2.1 THEORETICAL FRAMEWORK

This section provides an overview from the literature describing user acceptance to understand what user acceptance is and how it is impacted, specifically in the context of agriculture, while encompassing models that are also used in other technology fields, such as Information Technology and software development.

2.1.1 Technology Acceptance Models

Several factors influence farmers' acceptance or adoption of new IoT applications, tools or services for improving their farm management and decision-making processes.

According to the Technology Acceptance Model (TAM), the main factors for technology adoption are usefulness and ease of use (*Figure 2*). If farmers believe the new technology will enhance their performance, they are more eager to apply technology in their daily practice (Davis, 1989; Flett et al., 2004).

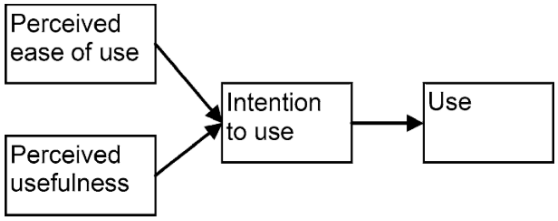


Figure 2: basic TAM assumptions (Davis, 1989), figure from (Heerink et al., 2010)

If farmers believe that an IoT solution is easy to use, their attitude toward IoT solutions will be more positive and adoption will be more plausible (Davis, 1989; Rothensee, 2008). Eventually, users need to perceive positive economic value for IoT applications (Adrian, Norwood, & Mask, 2005; Flett et al., 2004; Rothensee, 2008). A study in New-Zealand reported that farmers indicate not using a technology even when that technology is relevant and important to their farming needs, meaning despite its perceived importance (Flett et al., 2004). This indicates that besides ease of use and usefulness other factors, such as positive economic value, can influence user acceptance. The basic Technology Acceptance Model in that sense could be insufficient when validating user acceptance of IoT solutions in the agri-food context.

TAM has been adapted and expanded with additional constructs in later research and in several contexts, from consumer acceptance of IoT (Gao & Bai, 2014) to acceptance of social robots (Heerink et al., 2010; Heerink, Krose, & Wielinga, 2009). In 2003, Venkatesh et al. offered an overview of post-TAM technology acceptance models and added the most reliable constructs into the Unified Theory of

Acceptance and Use of Technology (UTAUT) model (3). The UTAUT theory explains intention to use in terms of variables like perceived usefulness and perceived ease of use, which are related to functional or utilitarian evaluation, but also social interaction variables. Furthermore, the perceived usefulness of the technology takes a broader definition and is renamed to performance expectancy and includes the expectations the user has of the performance of the system. Perceived ease of use is also renamed into effort expectancy, which means the expectations the user has of the effort that is needed to use the system.

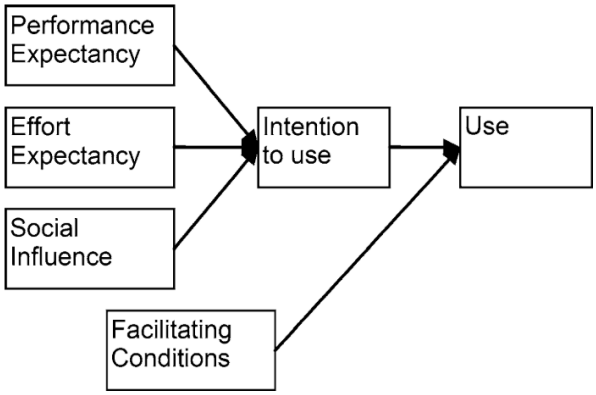


Figure 3: UTAUT model (Venkatesh et al., 2003), figure from (Heerink et al., 2010)

Other factors that were incorporated into the new model are social influence and facilitating conditions (Venkatesh et al., 2003). Social influence was found to be the second largest effect on behavioural intention by Gao & Bai (2014) in a research aiming to develop factors determining consumers' acceptance of IoT technology.

2.1.2 User acceptance in the agricultural sector

Five different categories that influence user adoption in the agricultural sector can be distinguished by: informational factors, behavioural and social factors, business and economic factors, technological factors and external factors (Dillen, 2020).

The informational factors are crucial in technology uptake, as farmers can only adopt a technology once information about this technology and its benefits are shared with them (Rogers, 1995). While some farmers can be very active in seeking information about new technologies, others might only become aware of the technology mainly by their direct environment, for example via peers or family (Ramirez, 2013; Rogers, 1995)

The behavioural and social factors include age, culture, education and location, but also the perception and attitude of the farmer itself. Besides the usefulness and ease of use of the solution, core values and norms guide farmers' individual attitude and opinion towards technology in general are essential. Farmers' beliefs, such as negative feelings toward technology – feeling of added complexity and distrust in technology - play a significant role in technology uptake (Lima et al., 2018). From a sociological perspective, the influence of social networks – e.g. dominant attitude of farmers' community – on his attitude and acceptance is certainly relevant. Farmers' adoption behaviour of technology may be influenced by knowledge transfers in their day-to-day interactions within their sub-groups (Ramirez, 2013). Other farmers are main sources of farmers' knowledge (Ramirez et al., 2010). Trust among farmers is one reason why advice and other types of knowledge from fellow

farmers play an important role in farmers' adoption behaviour. This suggests that participation in organizations can be a key factor influencing farmers adopting technology (Ramirez, 2013). Farmers' organizations can facilitate transfers of technology through exchange of information and ideas among farmers and farmers' organisations (OECD, 2001:25).

And from a psychological perspective farmers' envisaged or perceived risks and, on the contrary, trust in promised benefits of ICT products and services are also relevant variables. Social characteristics of farmers – such as the attitude towards risk and openness of the farmer – influences the use of internet applications (Taragola & Lierde, 2010). Studies on farmers that already have adopted precision agriculture technologies showed that farmers' confidence with computers, which is regarded as a social demographic factor, is a very important driver affecting technology adoption (Pierpaoli et al., 2013). Farmers can be sceptical of new technology when the technology sector is not delivering reliable, accurate technology (Bindi, 2017).

A more recent study in Italy investigated the process of technology adoption amongst farmers related to precision agriculture (Vecchio, De Rosa, Adinolfi, Bartoli, & Masi, 2020). A questionnaire was used to apply the AKAP (Awareness, Knowledge, Adoption, Product) sequence, defining the natural order of steps leading up to the adoption of an innovative solution. Analysis showed that context-related factors are fundamental in the exploration of use acceptance in order to specify uptake of precision farming tools.

The business and economic factors concern, for example, the farm size and investment costs of the technology. Due to higher income levels, larger farms may be more willing and able to adopt new technologies. For example, Lawson et al. (2011) found that the size of the farm has a significant positive effect on the adoption of agricultural technologies, with larger farms using more technologies compared to smaller farms.

The technological factors are about the user perception of the technology (ease of use, usefulness, compatibility, relative advantage etc.). To ensure user acceptance, IoT applications should meet certain technical and technological quality and interoperability standards, such as compatibility with existing technologies and systems, infrastructures, and processes. Moreover, farmers' capacity and knowledge to handle new technology can have effect on their acceptance level.

Finally, the external factors refer to the other actors that have an influence in the chain and can encourage or discourage them to use a certain technology (regulator, customer, retailer etc.).

2.2 IOF2020 UAT FRAMEWORK AND HYPOTHESES

Based on the literature, 6 basic concepts are relevant to adoption of agri-tech IoT solutions in IoF2020. User acceptance is reached when an end user actually uses the product and is pleased with the solution at the same time, depending on their experience with the technology. Is the solution useful and easy to use? Usefulness, ease of use, performance expectancy and knowledge transfer are expected to influence the intention of a farmer or other end user to use the solution. This approach is in line with the theory as described by Davis (1989), but does not take into account any factors in the surroundings of the end user or in the context of the solution. It is also important that the end user perceives the economic value of the solution and that the solution actually works at the farm. Would a farmer use the IoT solution if it works well, is easy to use but too expensive or if 4G connectivity is not adequate for real-time data exchange?

These concepts, or constructs, are bundled into a proposition that together impact the user acceptance, as displayed in *Figure 4*.

It is expected that usefulness, productivity, ease of use and knowledge transfer impact the intention of the end user to use the solution. And where Davis states that intention to use impacts the actual usage of technology, we add perceived economic value and facilitating conditions (Venkatesh et al., 2003) as factors in the environment of the user that also impact actual usage. The results of this research may find support for these expectations, based on theory.

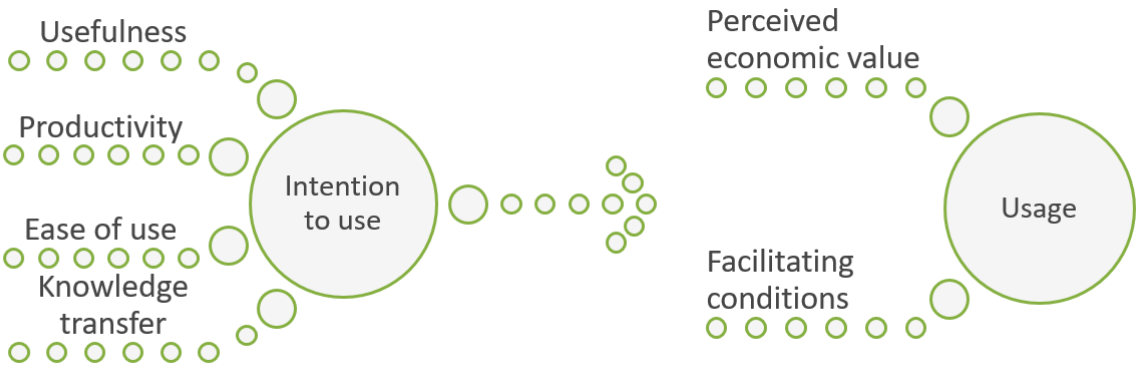


Figure 4: applicable constructs for IoF2020

For the quantitative data collection activity of this research (Section 5), the hypotheses below are relevant to understand user acceptance. Productivity is not expected to directly relate to usage, but the intention to use, in line with the theory stating farmer performance impacts the eagerness to apply the technology (Davis, 1989; Flett et al., 2004). Infrastructure and interoperability are new elements that were added, because it is expected that the farm infrastructure and interoperability play a role in user acceptance.

Intention to use

1. The usefulness of the solution relates to the intention to use the solution.
2. The usefulness of the solution relates to user confidence.
3. Farm infrastructure and interoperability relate to the intention to use the solution.
4. Farm infrastructure and interoperability relate to user confidence.
5. The ease of use of the solution relates to the intention to use.
6. The ease of use of the solution relates to user confidence.
7. Knowing about experience by fellow farmers relates to the intention to use the solution.
8. Knowing about experience by fellow farmers relates to user confidence.

Usage

9. Increased productivity and profit relate to usage of the solution.
10. Facilitating conditions relates to usage of the solution.

3 USER ACCEPTANCE METHODOLOGY

This section describes the methodology used for the research into user acceptance in IoF2020 use cases. The main 6 research activities were performed along 3 research phases: literature review, data collection and data analysis (*Table 1*).

Research activity	Research phase
1. Literature framework	Literature review
2. Questionnaire development	Quantitative data collection
3. Survey distribution	
4. Interviews	Qualitative data collection
5. **Data quantitative analysis (Qualtrics, Excel, R)**	Quantitative data analysis
6. Data qualitative analysis (Tabulation, Atlas.ti)	Qualitative data analysis

Table 1: research activities by research phase

The WP4 user acceptance team stayed in close contact with the use cases through trial meetings and 2 webinars were organized to share and demonstrate user acceptance testing knowledge to other projects and Digital Innovation Hubs (DIHs). A full overview of use cases that participated in these activities is presented in *Appendix 1: UAT Status per Use Case*.

The quantitative and qualitative data that was collected, such as Excel files with downloaded respondent data, recorded interviews and interview transcripts, were stored in a secured Sharepoint location and kept confidential under the IOF202 framework, GDPR and IoF2020 Data Management Plan (DMP).

First, a scan of literature on user acceptance was performed by searching the WUR library as point of first key word search (IoT, User Acceptance, Agri Food, Agri Products, TAM, digitalization, consumer acceptance, robotics, user perception, technology adoption). The snowball method was used to find related relevant references used. The aim was to include the key user acceptance studies in the European agriculture context.

Second, based on the literature review, we have created the framework that combines and integrates user acceptance related constructs that are relevant and even crucial for agri-food sector. Using the framework, we have developed the questionnaire, which has been translated into a survey form. To make the survey easily accessible and user-friendly, we have transformed the questionnaire into an online survey tool using the Qualtrics software. The survey contained 44 mainly closed questions in the Likert scale of 5 (Strongly agree to strongly disagree). The response would normally take not more than 15 minutes to complete. After several internal quality reviews (*Appendix 6: UAT questionnaire*), we have provided the Qualtrics link to the use case leaders who could easily take the questionnaire to their end user. The survey is user friendly and has mobile version as well (*Figure 5*).

The use case leaders asked the end users of the IoT solution they developed within the use case to fill-in the survey. Sometimes, due to language issues the use case leaders translated the questionnaire, asked themselves the questions directly and then filled in the result in Qualtrics afterwards. The quality of translations and validity of the data has not been double checked and is based on the trust and professionality of the use case leaders.

All use cases were prompted to respond. However, some use cases were not yet in the phase that user acceptance testing would provide useful results. A full overview of use cases that participated in UAT activities, please refer to *Appendix 1: UAT Status per Use Case*.

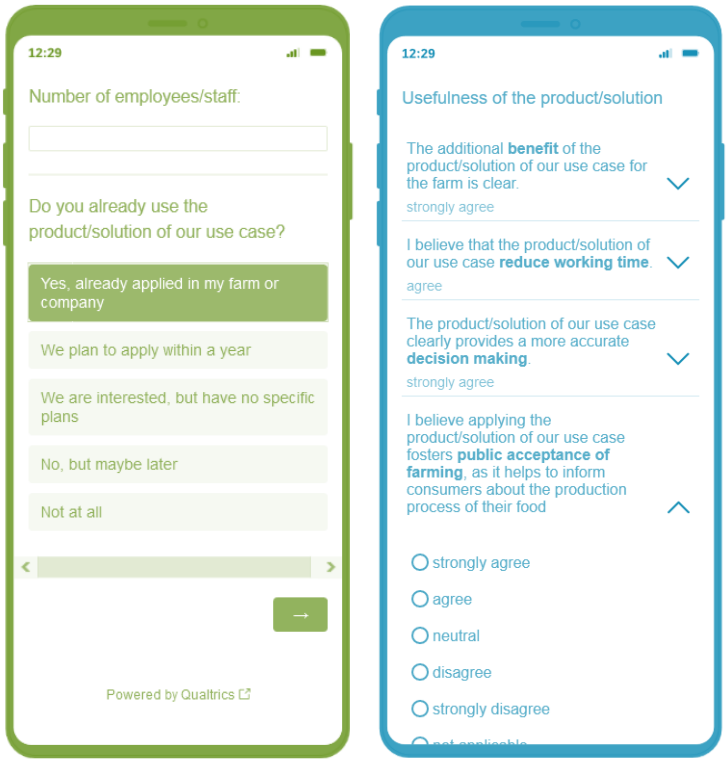


Figure 5: screen captures of mobile version of Qualtrics questionnaire

Third, besides the relatively long version of the survey provided via Qualtrics, we have created a short feedback questionnaire which has been used for a quick feedback during trial meetings. Usually, the use cases within the same trial used to meet physically in a location. The user acceptance team made sure to have at least one representative in all the trial meetings. During these meetings, we have provided the paper version of the short questionnaire to all participants of the meetings, and asked them to fill-in the feedback form right after each use case had presented the MVP of their IoT solution. Although the respondents of this short survey were not end users, they were professional and experienced in IoT. Therefore, their feedback has been evaluated as very valuable and useful by the use cases and has been used as input for a rating on user acceptance.

Fourth, we have conducted 9 virtual in-depth interviews with end users of the solutions developed in 9 selected use cases. These interviews using online video had several goals:

- validate user acceptance data gathered from the long questionnaire,
- overcome lack of data due to many missing values in completed survey responses;

- uncover new insights into user acceptance and comprehend the quantitative data with new learnings.

The interviews were conducted among selected use cases that have a higher overall business and market readiness level. This selection criteria ensured that interviewees had experience in the use of IoT solution. The virtual interview was conducted using semi-structured questionnaire and took about 60 minutes. The representativeness of these interviews for the IoF2020 trials was assured by interviewing at least one end user from each of the 5 trials.

Fifth, we used quantitative data analysis methods to analyse the relationships between constructs, such as ease of use and intention to use (see *Figure 4*) . The hypothesis was that usefulness, ease of use and farm infrastructure are related to the intention to use the solution and confidence (see *Appendix 2: Correlation Overview*). As the number of observations was limited due to many missing values, we used the Fisher's exact test statistics. To quantify the strength of the relationship between different constructs, effect sizes were calculated using Goodman-Kruskal's gamma. A more detailed description of the applied analysis is given in *Appendix 3: Correlation analysis*. The results are presented in section 5.

Sixth, the 9 in-depth interviews have been recorded, transcribed and analysed using Atlas.ti software. Content analysis of the transcribed text was to understand the level of user acceptance across all use cases and combine the findings with survey responses. We used a top-down coding approach in content coding. We agreed upon a list of fixed codes that define usefulness and ease of use at a detailed level, based on Davis (1989). During the coding, additional 'open' codes were added to indicate additional insights and to use quotes of what was stated during the interviews.

4 RESULTS SURVEY

Across all use cases, the user acceptance is evaluated to validate to which extent end users accept the IoT solutions. Next, we look at how constructs found in the literature relate to each other in practice.

4.1 DATA COLLECTION OVERVIEW

An overview of responses for the questionnaire presented below. Out of 159 initial responses, 57 were completed and they represent 25 out of 33 use cases. It should be noted that some use cases provided more than one response (sometimes by the same person) and some use cases could not. The distribution between test farms and companies is well spread. The age of respondents is mostly between 30-49 years, although 40% of responses is unknown. All questions are listed in the questionnaire in *Appendix 6: UAT questionnaire*.

Test farm / company		**Percentage**
Company	75	48%
Test farm	73	44%
Unknown	11	7%
Total	**159**	**100%**

Age		**Percentage**
< 29	17	11%
30-39	33	21%
40-49	31	19%
50-59	10	6%
60 +	4	3%
Unknown	64	40%
Total	**159**	**100%**

Table 2: overview of survey respondents

4.2 OVERALL USER ACCEPTANCE

To describe the extent to which end users in the IoF2020 use cases accept the innovative IoT solutions, the research defines the following concepts:

- **Usefulness**: how useful is the IoT solution to the end user?
- **Perceived economic value, cost and productivity**: how does the user perceive the economic value to the farm/company? How does the end user perceive cost and impact on productivity?
- **Ease of use**: how easy can the end user use the IoT solution?
- **Knowledge transfer**: how does usage by other farmers impact user acceptance?
- **Facilitating conditions**: what conditions are important for the end user to be able to work with the solution?
- **Usage**: to what extent does the end user actually work with the IoT solution?

These concepts allow a detailed analysis to validate user acceptance, and uncovers the real constructs behind the user acceptance. Below, we describe the results of this report by each of these concepts.

4.2.1 Usefulness

The results of usefulness assessment of the IoT solution by farmers is presented in *Table 3*.

#	Field	strongly agree	agree	neutral	disagree	strongly disagree	Total
1	The additional benefit of the product/solution of our use case for the farm is clear.	46.15% 18	48.72% 19	5.13% 2	0.00% 0	0.00% 0	39
2	I believe that the product/solution of our use case reduce working time.	31.58% 12	55.26% 21	10.53% 4	2.63% 1	0.00% 0	38
3	The product/solution of our use case clearly provides a more accurate decision making.	42.50% 17	47.50% 19	10.00% 4	0.00% 0	0.00% 0	40
4	I believe applying the product/solution of our use case fosters public acceptance of farming, as it helps to inform consumers about the production process of their food	34.38% 11	34.38% 11	28.13% 9	3.13% 1	0.00% 0	32
5	I believe applying the product/solution of our use case contributes to realizing societal goals, such as making farming more environmentally friendly.	26.32% 10	39.47% 15	23.68% 9	5.26% 2	5.26% 2	38
6	I think that the product/solution of our use case offers me more benefits than current practice.	44.74% 17	47.37% 18	7.89% 3	0.00% 0	0.00% 0	38

Table 3: usefulness – farmers' responses

> *"The additional benefit of the product/solution of our use case for the farm is clear."*
>
> ***37 farmers out of 39 either agree or strongly agree***

As Table 3 shows, a vast majority of farmers either agreed or strongly agreed that the benefit of the solution was clear and only 5% was neutral to this, while no one disagreed (question item #1 in *Table 3*).

To the question if the solution reduces working time, 21 farmers agree and 12 strongly agree (item #2). This trend continues for the following topics too, specifically, the usefulness in accurate decision making (item #3) and usefulness in informing consumers about food production (although the total response is 32, which is somewhat lower for this last item #4).

> *"I believe that the product/solution of our use case reduces working time."*
>
> ***33 farmers agree or strongly agree (out of 38 responses)***

We do see a higher neutral number of responses for item #4 as well, as for item #5, which could indicate that these respondents do not fully agree to these statements and reaching societal goals is even disagreed to by 2 respondents (item #5). Whether the solution has more benefits than current farming practices is also generally agreed to by 35 out of 38 responses (item #6).

The results of usefulness assessment of the IoT solution by companies is presented in *Table 4*.

#	Field	strongly agree	agree	neutral	disagree	strongly disagree	Total
1	The additional benefit of the product/solution of our use case for the company is clear.	38.24% 13	55.88% 19	5.88% 2	0.00% 0	0.00% 0	34
2	I believe that the product/solution of our use case reduce working time.	33.33% 11	42.42% 14	9.09% 3	12.12% 4	3.03% 1	33
3	The product/solution of our use case clearly provides a more accurate decision making.	38.24% 13	52.94% 18	8.82% 3	0.00% 0	0.00% 0	34
4	I believe applying the product/solution of our use case fosters public acceptance of farming, as it helps to inform consumers about the production process of their food	25.00% 7	42.86% 12	28.57% 8	3.57% 1	0.00% 0	28
5	I believe applying the product/solution of our use casecontributes to realizing societal goals, such as making farming more environmentally friendly.	35.48% 11	35.48% 11	19.35% 6	6.45% 2	3.23% 1	31
6	I think that the product/solution of our use case offers me more benefits than current practice.	38.24% 13	50.00% 17	11.76% 4	0.00% 0	0.00% 0	34

Table 4: usefulness – companies' responses

Compared to farmers' responses, companies have slightly lower response rate of about 30 per item and a similar positive response to usefulness. 31 companies out of 34 responses '(strongly) agree' that the additional benefits are clear. Similar to farmers' response, company respondents also agree that the solution fosters public acceptance, and believe the IoT contributes to realizing societal goals.

> *"I believe that the product/solution of our use case reduce working time."*
>
> ***25 companies agree or strongly agree (out of 33 responses)***

The number of respondents working at companies that agree to reduced work time is still quite high though, but lower compared to farmer respondents.

Based on the quantitative data on usefulness, we can summarize that key experiences for usefulness are mostly positive for both farmers and companies.

4.2.2 Perceived economic value, cost and productivity

The perceived economic value of a solution is built up out of the perceived price, cost and productivity on the farm. Even though some IoF2020 use cases have not yet decided upon pricing strategy, the responses on "*How much do you pay (planned to pay) for the product/solution of our use case?*" provide rich in-depth insights. *Figure 6* shows the main responses out of 33 responses for perceived economic value and illustrates the dependencies for setting an acceptable price for farmers.

> *£375 annually per device. €5? Depends on herd size, situation, application. Irrelevant. Not applicable yet. Less than €250 / each device. 5.000. 0 Depending on the product quality and production. Depending on the crop yield. Depends on the number of animals and the meters of the farm. Depends of the final product/solution. It's difficult to know which is the price... for the time being: use for free as trial farmer, Tag + baseplate at silo: 15.0€ /silo: 1/ trailer : 950.00€ / machine - PLC system + wireless charger + can device : 1/ trailer :3500.00€ / machine - access to database: to be , Pending to define the business model of the dashboard. free of charge (200k p.a.).*

Figure 6: responses on pricing and value

For example, it could depend on the size of a herd, farm size, the functionality of the solution (product) and access to data. Pricing can also be set in various ways, annually, per device, trailer, etc.

The second construct used to measure user acceptance is the cost and productivity. *Table 5* summarizes the responses of farmers regarding cost efficiency and productivity

#	Field	strongly agree	agree	neutral	disagree	strongly disagree	Total
1	Using the product/solution of our use case can increase my farms productivity.	21.62% 8	56.76% 21	18.92% 7	2.70% 1	0.00% 0	37
2	Using the product/solution of our use case can increase my profits.	16.22% 6	59.46% 22	24.32% 9	0.00% 0	0.00% 0	37
3	Using the product/solution of our use case can reduce my costs.	11.11% 4	61.11% 22	19.44% 7	2.78% 1	5.56% 2	36
4	The price/quality ratio of the product/solution of our use case is fair	7.69% 2	30.77% 8	50.00% 13	11.54% 3	0.00% 0	26
5	I would recommend the product/solution of our use case to my neighbours and fellow farmers.	27.27% 9	54.55% 18	18.18% 6	0.00% 0	0.00% 0	33

Table 5: cost and productivity – farmers' responses

Farmer respondents generally agree that IoT solutions increase productivity and profit, and reduce costs. 10 out of 26 respondents (strongly) agree that price/quality ratio of the solution is fair. However, the 13 out of 26 remained neutral to this statement (*Table 5*).

Farm productivity is generally seen as improved, although 7 out of 37 respondents are neutral to this.

> *"Using the product/solution of our use case can increase my profits."*
>
> ***28 farmers (strongly) agree, 9 farmers are neutral (out of 37 responses)***

When asked why farm productivity is increased, farmers provided several answers

> *"Thanks to the geo-localisation I can follow my team efficiency"*
>
> *"Ability to quickly react to changed cultivation circumstances."*
>
> *"The pooling network gets more efficient."*
>
> *"Because we can control the olive and quality."*
>
> *"You get the data and controlling the product/solution of our use case can reduce my costs."*

Additionally, *Table 4* shows that 28 out of 33 respondents from farms would recommend the solution to other companies, while 6 farmers are neutral to this statement.

Table 5 shows the perceptions of cost and productivity benefits of IoT solution by companies. We see a similar trend despite the fact that the number of responses is slightly lower. For both end user types the question is the price/quality ratio is fair shows less response. This could indicate that the respondents are unsure about the answer, presumably due to obscurity of the solution price.

> *"Using the product/solution of our use case can reduce my costs."*
>
> ***16 companies (strongly) agree, 10 companies are neutral (out of 27 responses)***

#	Field	strongly agree	agree	neutral	disagree	strongly disagree	Total
1	Using the product/solution of our use case can increase my companys productivity.	28.57% 8	46.43% 13	25.00% 7	0.00% 0	0.00% 0	28
2	Using the product/solution of our use casecan increase my profits.	18.52% 5	44.44% 12	33.33% 9	3.70% 1	0.00% 0	27
3	Using the product/solution of our use casecan reduce my costs.	25.93% 7	33.33% 9	37.04% 10	3.70% 1	0.00% 0	27
4	The price/quality ratio of the product/solution of our use case is fair	15.00% 3	50.00% 10	35.00% 7	0.00% 0	0.00% 0	20
5	I would recommend the product/solution of our use case to other companies.	28.00% 7	48.00% 12	24.00% 6	0.00% 0	0.00% 0	25

Table 6: cost and productivity - company responses

Based on the quantitative data, we can summarize that key experiences for cost and productivity are mostly positive for both farmers and companies.

Finally, *Table 7* below summarizes the responses to the open "*What makes the IoT solutions of IoF2020 increase farm and company profit?"*

Benefit / Revenue / profit	More soya.	More revenue.	Higher yield/quality	Variable Rate Application (VRA) contributes for a higher yield.	Increased breeding yield.	Faster reproduction generate clear profit, more intelligent fertilization, higher productivity increases profit.
Cost	Less costs.	Less veterinary costs.	Less recovery cost due to wrong deliveries.	Electricity savings.	Lower cultivation and irrigation costs.	Decrease monitoring costs and losses.
Productivity / efficiency	The pooling network gets more efficient, because maybe we can improve our distribution system and we will be able to improve animals growth tax.	Increased production.	We can work on other things due to automation	Better harvest quality.	Quick intervention possible.	Due to known bottlenecks we have the chance of improvement.

Accuracy / quality	Based on actual data more accurate watering and fertilization can be done.	Due to known bottlenecks we have the chance of improvement.	Because we will be able to track and trace our assets.	24/24 extra set of eyes in the barn.	Able to create an equilibrium between soil and crop productivity.	Because the output is always on time and on the same amount and quality level.
Other	Less animals drowning.		Quality aspects become tuneable.			

Table 7: Summary of how IoT improves productivity

4.2.3 Ease of use

Table 8 combines the assessments of farms and companies about the ease of use.

#	Field	strongly agree	agree	neutral	disagree	strongly disagree	Total
1	The product/solution of our use case was easy to install.	32.26% 20	45.16% 28	17.74% 11	4.84% 3	0.00% 0	62
2	The design of the solution is easy to understand.	28.13% 18	56.25% 36	12.50% 8	3.13% 2	0.00% 0	64
3	The workflow of the solution is logically and delivers the result with few clicks.	29.03% 18	54.84% 34	12.90% 8	3.23% 2	0.00% 0	62
4	Accessing the solution on my mobile device works properly.	23.73% 14	50.85% 30	20.34% 12	5.08% 3	0.00% 0	59
5	The use of the product/solution of our use case needs special (ICT) expertise.	6.35% 4	19.05% 12	28.57% 18	33.33% 21	12.70% 8	63
6	The product/solution of our use case was easy to use and understand by all persons working with it.	22.58% 14	58.06% 36	14.52% 9	4.84% 3	0.00% 0	62
7	If not, which features where complex for your personnel to understand (open question).	33.33% 4	25.00% 3	41.67% 5	0.00% 0	0.00% 0	12
8	Support service and guarantees are provided in case of malfunction.	37.29% 22	45.76% 27	16.95% 10	0.00% 0	0.00% 0	59

Table 8: ease of use - farm and company respondents

As *Table 8* shows, most of the items received agreed or strongly agreed with the items that indicate ease of use. What stands out in the table is the item related to the need of special (ICT) expertise in using IoT solution. Here the responses vary greatly: 16 out of 63 respondents agree or strongly agree that the use of IoT solution requires special expertise, whereas 29 respondents disagree or strongly disagree, and when 18 respondents are neutral. The number of neutral responses and 21 responses that disagree can be seen as positive, because if a user doesn't need special expertise, the ease of use of the solution is impacted in a positive way.

"The design of solution is easy to understand."

54 of end users (strongly) agree, 8 are neutral and 2 disagree (out of 64 responses)

4.2.4 Knowledge transfer

End users are expected to adopt technology easier when they interact within their sub-groups and exchange knowledge and experience. As *Table 9* shows, the majority of the IoF2020 end users agree (19 out of 34) and strongly agree (9 out of 34) that it is important for them to know the experience of fellow farmers about digital solutions. An interesting aspect of *Table 9* is that none of the respondents disagree or strongly disagree, whereas 6 responses are neutral.

Q22_5 - It is important for me to know the experience of fellow farmers about digit...

#	Field		Choice Count
1	strongly agree	26.47%	9
2	agree	55.88%	19
3	neutral	17.65%	6
4	disagree	0.00%	0
5	strongly disagree	0.00%	0
			34

Table 9: importance of experience of other farmers

Related to a knowledge is the prior knowledge, related to agri-technology, a farmer may have. The interview data in section 5.2.1 include any prior agri-tech knowledge end users may have.

4.2.5 Facilitating conditions

Facilitating conditions are important for the end user to be able to work with the IoT solution. To uncover what conditions are important for the end users to be able to work with the solution, and what issues hinder the IoT applications, the survey provided a list of possible conditions and hindrances.

Figure 7 summarizes the responses by each facilitating condition and issues.

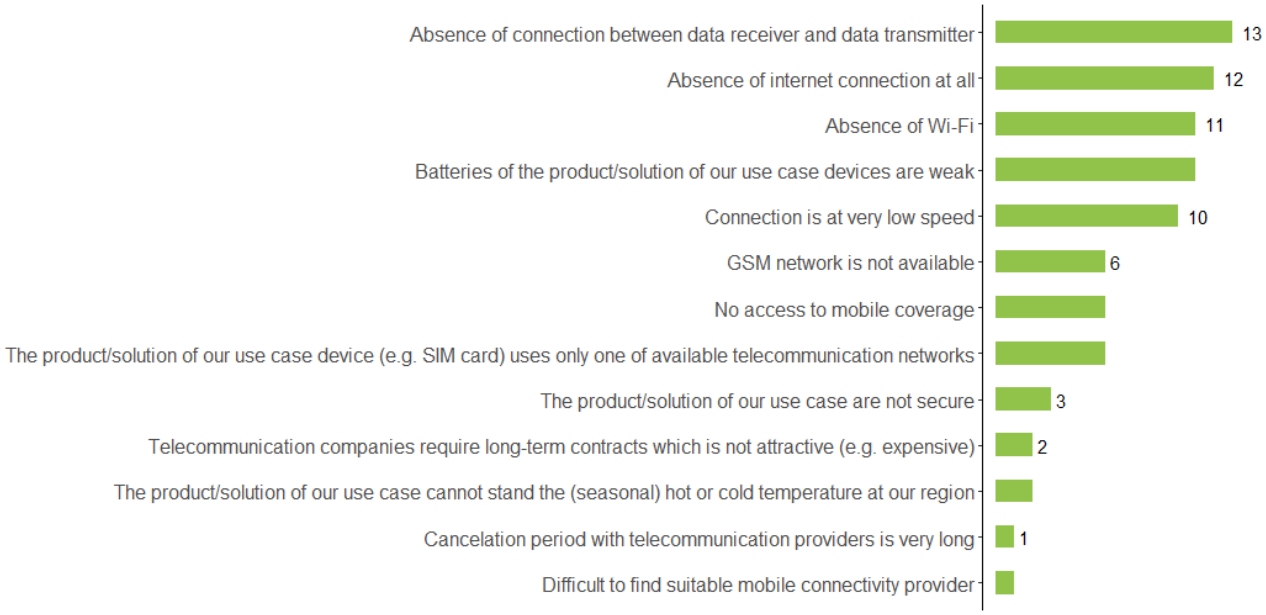


Figure 7: facilitating conditions and issues hindering application of the solution

The most striking, but also expected result to emerge from *Figure 7* is the importance of connection between data receiver and data transmitter, presence of internet connection and availability of WiFi. Evidently, internet of things needs internet connection to function. However, the responses indicate that these are still issues in IoF2020, and so indicate that remote areas, such as farm field, are not fully covered by (high speed) wireless connections. The next highly ranked issue is the battery life. The responses to the open ended sub question ("Other, please specify") in *Figure 8* provided additional insights.

"We need to find the trackers, when the battery is empty."

"Require maintenance since the farms are not fenced."

"There are problems with vandalism."

"Mobile network issues due to border region (Italy)."

"Accuracy of device."

"Network coverage could be weak in some regions."

Figure 8: other facilitating conditions

4.2.6 Usage

The model shown in *Figure 4* indicates that actual use of the technology depends on the intention to use. To measure the extent to what end users actually work with the IoT solution, we asked the actual use, intention to use and confidence in using the IoT solution.

Actual use:

The first question is to find actual use: "*Do you already use the product/solution?*". The majority of the respondents (67% or 60 out of 90 responses) responded positively indicating that they currently use the product (*Figure 9*). Interestingly, the number of responses to this question is relatively high (95 responses).

Intention to use:

The second question is to find intentions to use, e.g. plan to apply within a year, interested, maybe later. These are specifically relevant for the use cases that have not yet have their product installed at the end users. *Figure 9* shows that 19% of the respondents indicate to have a clear intention to use the solution and 7% indicate that they are interested even though they have no specific plans. Only 7% has no intention to use with an open possibility for the future.

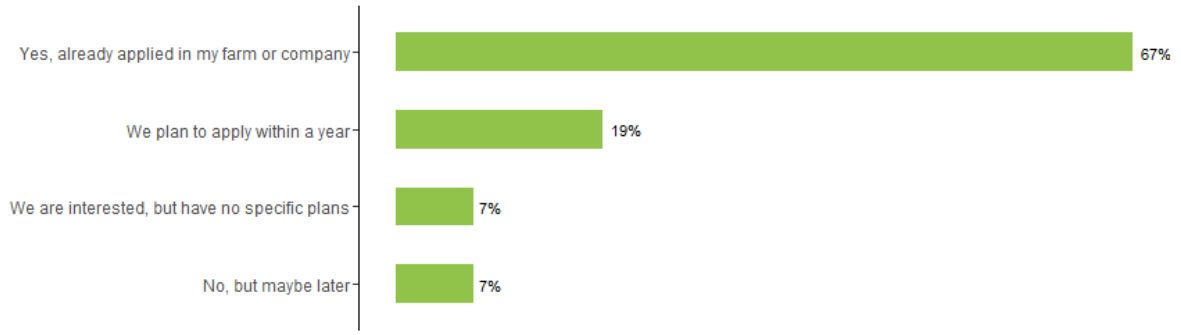


Figure 9: usage of product/solution

Confidence in using the solution:

Figure 10 shows a high level of confidence in the IoF2020 use case solutions: 66% feel confident and 19% feel very confident (based on 60 responses).

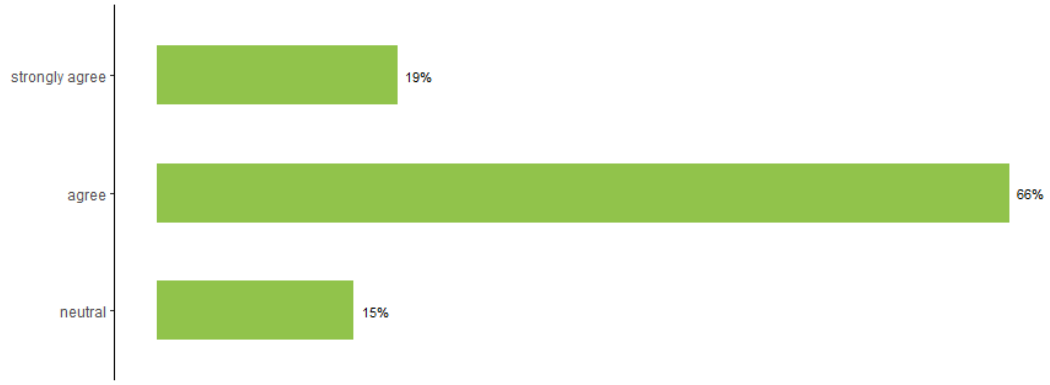


Figure 10: confidence about IoT solutions

To summarize the data from the questionnaire key experiences for usefulness are mostly positive for both farmers and companies and farmers generally agree that IoT solutions increase productivity and profit, and reduce costs. Farm productivity is generally seen as improved. Key experiences for cost and productivity are mostly positive for both farmers and companies. For farmers, it is important to know the experience of fellow farmers about digital solutions. The connection between data receiver and data transmitter, presence of internet connection, availability of WiFi and battery life are important facilitating conditions. The majority of end users actually use the product and feel confident using it.

4.3 CORRELATION BETWEEN CONSTRUCTS

This section investigates the hypotheses mentioned in section 2.2. The hypotheses aim to understand how user acceptance concepts relate to each other. It was if usefulness, farm infrastructure, ease of use and knowledge relate to the intention to use (hypothesis 1, 3, 5 and 7) and user confidence (hypothesis 2, 4, 6 and 8).

Intention to use

1. The usefulness of the solution relates to the **intention to use** the solution.
2. The usefulness of the solution relates to **user confidence**.
3. Farm infrastructure and interoperability relate to the **intention to use** the solution.
4. Farm infrastructure and interoperability relate to **user confidence**.
5. The ease of use of the solution relates to the **intention to use**.
6. The ease of use of the solution relates to **user confidence**.
7. Knowing about experience by fellow farmers relates to the **intention to use** the solution.
8. Knowing about experience by fellow farmers relates to **user confidence**.

Hypotheses 9 and 10 relate productivity and facilitating conditions to the actual use of the solution.

Usage

9. Increased productivity and profit relate to **usage** of the solution.
10. Facilitating conditions relates to **usage** of the solution.

Due to the relatively small size of the sample, the data analysis provided a limited set of significant correlations between these constructs, as described below. Other correlations besides the hypotheses 1-10 were investigated but not found to show a significant correlation. No causal effects were found in the data.

4.3.1 Confidence and ease of use, usefulness, technical quality

Correlation analysis found that user confidence relates to ease of use, technical quality & infrastructure and usefulness for the item: "*I am confident about using the digital solution*". *Figure 11* shows this correlation and the darker the colour green, the higher the number of responses is. To be fully clear on what it was that respondents were asked about, *Table 10* is an overview the survey questions.

Item name	Question asked
Delivers results fast	*Ease of Use:* The workflow of the solution is logical and delivers the result with few clicks.
Easy to install	*Ease of Use:* The product/solution of our use case was easy to install.
Easy to understand	*Ease of Use:* The design of the solution is easy to understand.
Easy to use	*Ease of Use:* The product/solution of our use case was easy to use and understand by all persons working with it.
Support service	*Ease of Use:* Support service and guarantees are provided in case of malfunction.
Infrastructure present to install	*Technical quality and infrastructure:* The company has all necessary infrastructure (examples listed below) to install the product/solution of our use case right away.
Benefit is clear	*Usefulness of the product/solution:* The additional benefit of the product/solution of our use case for the farm is clear.
More accurate decision making	*Usefulness of the product/solution:* The product/solution of our use case clearly provides a more accurate decision making.

Table 10: confidence with ease of use, technical aspects and usefulness

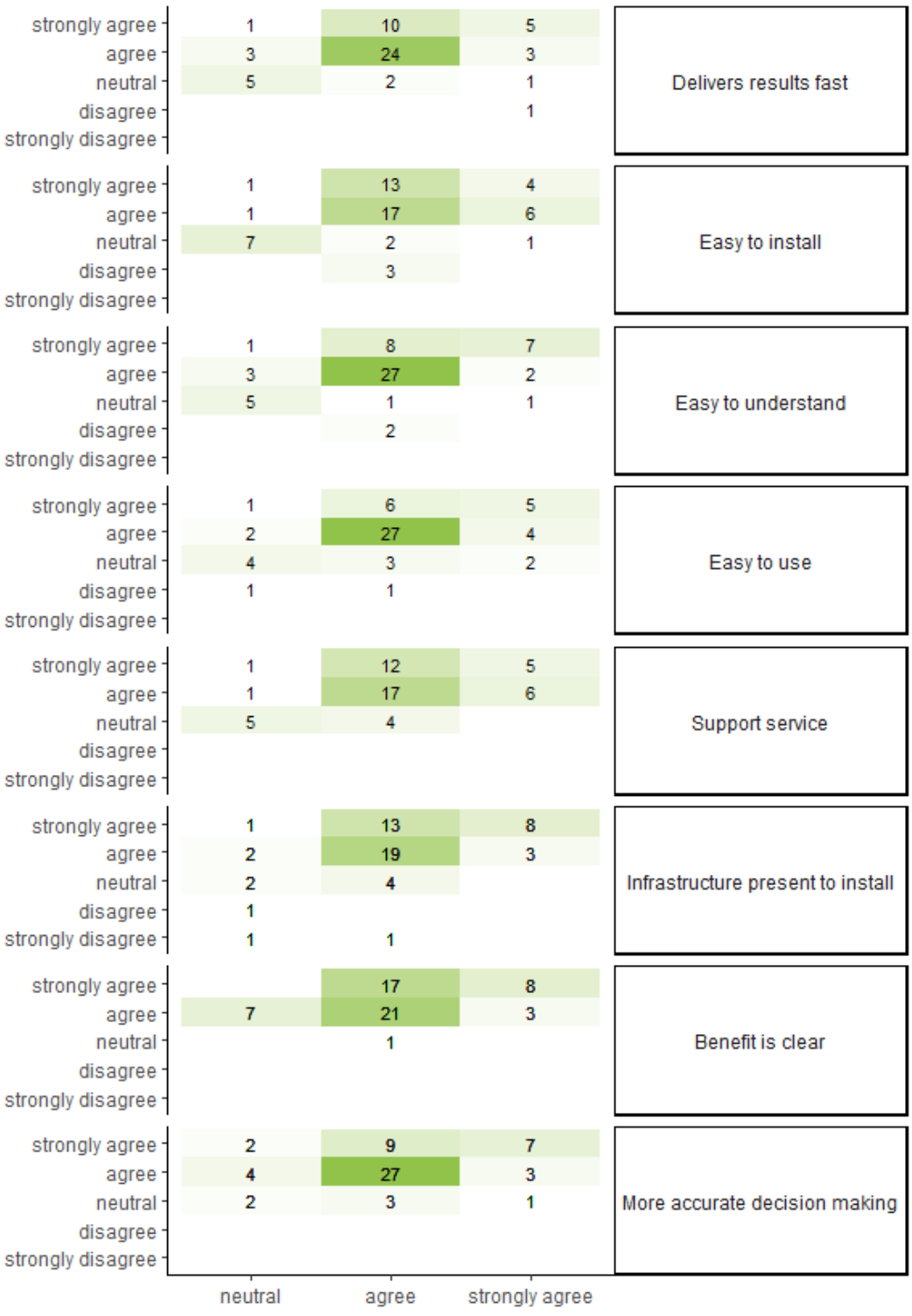


Figure 11: confidence related to usefulness, ease of use and technical quality

Figure 11 shows that 27 respondents are confident about the solution, and that they also agree the solution is easy to understand. Similarly, 24 respondents are positive that "*The workflow of the solution is logical and delivers the result with few clicks*" and 27 respondents agreeing to having

confidence in the solution also agree to "*The product/solution of our use case clearly provides a more accurate decision making*". For the hypotheses this means the following:

2. The usefulness of the solution relates to user confidence.

This hypothesis is confirmed by the data for clearly understanding the additional benefits of the solution (21 respondents agree) and more accurate decision making (27 respondents agree), because these respondents also agree to being confident about using the digital solution

4. Farm infrastructure and interoperability relate to user confidence.

This hypothesis is not completely confirmed by the data, because there is significant correlation with interoperability. User confidence does relate to the farm/company having the necessary infrastructure to install the product/solution of our use case right away, because the 19 respondents that agree to this, also agree to being confident about the solution.

6. Ease of use of the solution relates to user confidence.

This hypothesis is confirmed by the data. Especially in the sense that the solution is easy to understand, because the highest number of respondents (27) agree to being confident about the solution and the solution being easy to understand, easy to use and providing a more accurate decision making.

8. Knowing about experience by fellow farmers relates to user confidence.

This hypothesis is not confirmed by the data, because confidence was not found to relate to the importance of other farmers having knowledge about digital solutions. It was stated before (in section 4.2.4) that it is important for end users to know the experience of fellow farmers about digital solutions.

Hypotheses 1, 3, 5 and 7 relating to the intention to use are not confirmed by the data. This means it is not sure if usefulness, ease of use, farm infrastructure & interoperability and knowledge are related to the intention to use the solution.

Besides these hypotheses, support service and guarantees that were provided in case of malfunction were found to relate to confidence in the solution, because 17 respondents that agree to this also agree to being confident about using the digital solution (*Figure 11*).

4.3.2 Ease of use, technical quality and actual use

In addition to the descriptive data on the intention to use and actual use (see 4.2.6), the research aimed to understand the relationship between these concepts in more detail by analysing their correlation.

When asked about ease of use in the sense that the solution provides results quickly, the following questions showed correlation with the usage of the solution (*Figure 12*. The green areas in this chart indicate larger counts of respondents, already applying the solution in their farm or company, who agree to a large extent with the statements.

To be fully clear on what it was that respondents were asked about, *Table 11* is an overview of the questions.

Item name	Question asked
Delivers results fast	*Ease of Use:* The workflow of the solution is logical and delivers the result with few clicks.
Infrastructure present to install	*Technical quality and infrastructure:* The company has all necessary infrastructure (examples listed below) to install the product/solution of our use case right away.
Interoperable with other solutions	*Technical quality and infrastructure:* The product/solution of our use case is interoperable with all existing digital solutions and machines on the farm.

Table 11: ease of use and technical quality and infrastructure

Where 25 responses state 'agree' to "*the workflow of the solution is logical and delivers the result with few clicks*", there are 25 responses saying they apply the solution in the farm or company, therefore the test statistics show there is a relationship between the two concepts (*Figure 12)*. The farm or company '*having all necessary infrastructure to install the product/solution right away'* (21 respondents) and '*interoperability with existing digital solutions and machines on the farm*' (15 respondents) also relate to the actual use. This makes sense, because a user would have to have actually applied the solution in the farm to be able to have an opinion about speed, infrastructure and interoperability. We can confirm that these statements are then backed-up by actual use of the solution.

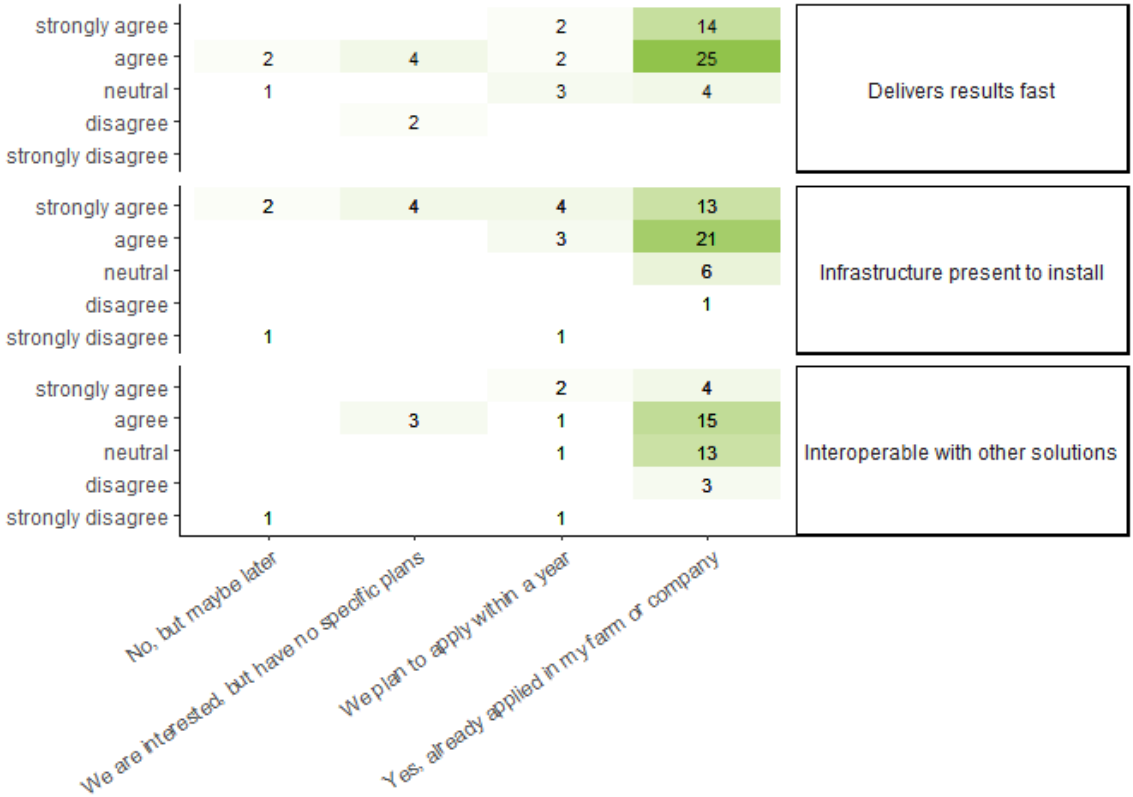


Figure 12: usage of the solution with ease of use and technical aspects

Actual use was expected to relate to increased productivity and facilitating conditions by the following hypotheses, but no significant relation was found for these hypotheses.

9. Increased productivity and profit relate to usage of the solution.

10. Facilitating conditions relates to usage of the solution.

4.4 PRELIMINARY OVERALL UAT RATING

Next to the direct feedback to the use case, another purpose of the user acceptance testing was to compare and rate the acceptance of different IoT solutions and to provide an overall impression about the user acceptance of IoF2020 solutions. This relates to the overall project objective O3 named "Validate User Acceptability" and its related key performance indicator (KPI) which is "User satisfaction of the demonstrated IoT solutions (scale of 5)". At the beginning, IoF2020 set itself the goal to reach an overall user acceptance of its IoT solutions of 4 out of 5.

No	Target Outcome	Key Performance Indicator (KPI)	Current Result	Goal
O3	Validated user acceptability	User satisfaction of the demonstrated IoT solutions (scale of 5)	3,9	4

In order to measure the above KPI, the user acceptance team of IoF2020 weighted the answers of the questionnaire and short survey to arrive at an overall result for each use case on a scale between 1 and 5. *Appendix 4: UAT rating* shows the list of use case rating. Averages were calculated where a use case provided more than 1 response. This final step resulted in an overall user acceptance rating that provide a view on user acceptance for use cases.

The results below are only presenting preliminary results as many use cases are still performing user acceptance assessments and not all results could be taken into account for this report. For the final results and more comprehensive statement on the performance of IoF2020 use cases in regards to the project objective of "Validated user acceptability" please refer to the final reporting of IoF2020 which is due in March 2020.

Overview of the current KPI measurements:

- **5 use cases rate 4.5 out of 5:**
  UC1.3, UC1.6, UC3.5, UC5.4 and UC5.5 have a rating of 4.5.

- **11 use cases rate 4 out of 5:**
  UC1.1, UC1.5, UC1.7, UC2.1, UC2.2, UC2.7, UC3.1, UC3.3, UC3.4, U4.1 and UC4.3 have a rating of 4.

- **4 use cases rate 3.5 out of 5:**
  UC4.5, UC5.1, UC5.2 and UC5.6 have a rating of 3.5.

- **1 use case rates 2.5 out of 5**:
  UC4.4 has a rating of 2.5.

- **No data (yet):**
  The UAT team is in touch with these use cases to retrieve information or the status will be gathered from the most recent Progress reports.

5 END USER INTERVIEW RESULTS

This section shows the results of the nine in-depth interviews with ends users. We first present descriptive information about the collected data. Then, the findings from all interviews are summarized per use case.

5.1 INTERVIEW DATA OVERVIEW

Among 33 use cases, 12 use cases were selected to participate in the interviews based on the progress in the development of the solution. Additionally, the selected use cases could (to our knowledge) bring-in their product end users to share their experience and give detailed feedback on the MVP circle the IoT solution has achieved. *Table 12* shows the overview of the interviewed use cases and in *Appendix 5: Overview interview results* a full overview of key findings is presented.

	Use case
1	1.1 Within field management zoning
2	1.6: Data driven potato production
3	1.8 Solar-powered field sensors
4	2.7: Multi-sensor cow monitoring
5	3.3 Automated olive chain
6	3.4: Intelligent fruit logistics
7	4.1 City farming leafy vegetables
8	5.4: Decision-making optimisation in beef supply chain
9	5.5 Feed supply chain management

Table 12: description of the interviewees and use cases

Below, the interview results are described per use case separately, then findings from Atlas.ti analysis and new insights are uncovered.

5.2 END USER RESULTS OF THE INTERVIEWS

Below, the interview results are described per use case separately.

1. ***Use case 1.1 Within-field management zoning (arable)***

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
Specific IoT devices for acquisition of soil, crop and climate data in production and storage of key arable and vegetable crops	Arable farm 600 acres	3 years	Owner of the farm	Bachelor in agriculture, lot of experience in using new technologies (precision agriculture)

The interviewee is a farmer, an owner of about 600 acres arable farm, currently uses the IoT solution developed within use case 1.1. He mentions to have some experience with technologies, and a bachelor in agriculture. The farmer states that he is using the technology only one month a year during the planting season. He received training on working with the platform of the IoT solution.

Objectives of the end user

The main objective of the farmer is to make variable rate maps for the fields in a more efficient and easier way compared to doing this manually.

> *"We work with over 180 fields of potatoes over 10 fields of sugar beets, 10 fields wheat, and some barley. We have a lot to manage. Therefore, IoT is unmissable at our farm."*

Ease of use and usefulness

The farmer thinks the solutions are very easy to use in terms of functions. Even after not using the solution for 11 months, he can still remember how it works.

> *"It's a very easy to use software that is doing what it's supposed to do. That's what I like about it."*
>
> *"The application is just the tool to automate the process that can also be done manually. It's not rocket science. It's just making things easier."*

However, he mentions that the solution is not interoperable with other (existing) systems, and is perceived as extra operation. Linking the solution to the existing platforms and making it available in more than one platform will, according to the farmer, ease his job. Furthermore, the usefulness of IoT is valued as it meets the expectations and demands. The farmer also thinks that the technology will be useful for smaller farms, as there are no investment costs involved. According to the

farmer, making these rate maps could improve economic returns and decrease environmental impacts[1].

Risks and/or challenges of IoT use according to the user

Technological

- Data is needed for using the solution — *"...the only thing that you need to take care of, is that the application needs data. And if the data is not there, then you can't use the solution ... One point that a lot of other users don't have- so that also could be a bit difficult."*
- Interoperability with other systems — "*One of those is that the tool is not only available in Akkerweb, but it should be available in other platforms."*

Willingness to buy

The farmer did not think that the solution would cost any money, besides the fact that needed data to be able to use the solution (see risks and challenges) might lack impacting on the willingness to buy.

> *"I'm just testing. I don't think it's a paid solution either. I think the solution is a free solution."*

Summary

Overall, the farmer thinks the solution is easy to use, although the interoperability with other systems can be improved. The solution meets his expectations and it is useful and for him, but also for other (smaller) farms as it does not require investments. One challenge however is that the solution needs data, which other farmers might not have.

2. *Use case 1.6 Data driven potato production (arable)*

Short description	**Farm/company type and size**	**IoT usage**	**Role interviewee**	**Prior agri-tech knowledge of the interviewee**
An innovative, market-ready smart farming solution supports irrigation, pest management and fertilisation.	Arable farm 300 hectares	<1 year	Quality controller of potato farm	Bachelor in agriculture and technical engineering

The interviewee is an end user of the solution developed within use case 1.6. She is the quality controller of a potato farm of about 300 hectares. She has received training on how to work with the machine on the field and how to work with the mobile application. She states that she was a bit suspicious about the accuracy of the solution in the beginning. The solution is used via the app mainly to get information on irrigation, as irrigation is the most important issue during the period when IoT was used. She had not yet used the pest and disease prediction functionality by the time of interview.

Objectives of the end user

The main objectives of the end user are to improve irrigation efficiency and to prevent the spread of pests and diseases on the potato field (pest and disease management).

[1] The consumer value of the IoT solution used in the use case are illustrated in drawings. These drawings are created by the artists of Flatlant company in a separate interview with the use case leaders. The drawings are presented in this report for illustrative purposes only.

Ease of use and usefulness

Overall, the interviewee perceives the solution as very easy to use and understand. She mentions that the solution decreases mental effort, frees up time to do other things, gives more control over the business, increases productivity and saves resources and money. According to her, the solution is reliable and provides guidance in performing tasks.

> *"It's very easy to use the new application, and to understand what it shows."*
>
> *"It helps me to do something else, to develop my business, to control better my business, to be sure of my business and in the end save some money for my business."*

According to the interviewee, ease of use and usefulness can however be improved, for instance, by receiving notifications also when not logged into the system. Furthermore, she states that the pest and disease predictions need to be developed further, and that the use case is working on that currently.

Risks and/or challenges according to the user

Business/economic

- Able to use less land where station is placed leading to less harvest yield.

"The area in which the station is located cannot be used for cultivation. Thus, we lose some potatoes harvest. However this loss is about 100 to 200 kilo. If you are a serious grower, you don't mind about it."

Behavioural/social

- Older generations might trust their own experience over the IoT data.

"It's not easy to make aged farmers understand and make them believe that this application is right. Often they reply "yes but I'm watching the farm for more than 50 years, and now you told me that I'm wrong and this thing is correct?".

Willingness to buy

The interviewee says she will buy the solution, as it saves time and resources.

> *"In the end the IoF (project) made me believe that I need it, for sure I need it."*

Summary

Overall, the interviewee is positive about the ease of use and usefulness of the solution so far, but there are still functionalities within the application that can be improved. She nevertheless is willing to buy the solution in the end. Two challenges for further adoption could be the placement of the station leading to less harvest yield and the fact that older generations might be more sceptical about the technology.

3. *Use case 1.8 Solar-powered field sensors (arable)*

Short description	**Farm/com-pany type and size**	**IoT usage**	**Role interviewe e**	**Prior agri-tech knowledge of the interviewee**
Solar-powered sensors bring a soil laboratory to the fields and allow end users to monitor and treat their crops in real time.	Arable (test)farm, 1 hectare	<1 year	Farm owner	Bachelor in physics, traditional farming technologies (tractor, water pumps)

The end user of the developed IoT solution in use case 1.8 is the owner of a potato farm and a few small test fields. Currently, he uses the solution only in his test fields, which are about 1 hectare. Furthermore, he received training on how to use and interpret the mobile app.

Objectives of the user

The main objective of the farmer is to use the recommendations given by the solution to use the correct amount of water (irrigation management), nutrients and fertilizers on the field.

Ease of use and usefulness

The user mentions that the systems and navigations are easy to understand. He thinks he receives correct values about the characteristics of the field from the app. He is mostly using the irrigation data from the app at this stage, and thinks it helps being more efficient in terms of water use.

> *"Although it's still the basic first phase of the app version, for me the new, the starting part, the testing period, it still gives us some nice logical values about the temperature, moisture and humidity"*

Ease of use and usefulness could however be improved according to the user by activating the camera option within the application and updating the disease prediction in the app. Furthermore, the user thinks the solution could be improved by making it possible to compare values in the app with a large database, and/or making the interface of the app more realistic. Another issue mentioned by the user was that it is not possible yet to mark the different fields on the map and that this is now only based on sensor data. The user indicated that the use case is currently working on this point.

> *"I would like to take a picture and send it to the centre. And then they can define, for example, the disease or what's wrong with my crops. The sensor doesn't give that much information. The cameras option in the app exists, but it's not used right now. It's not active."*

Risks and/or challenges

The interviewee mentioned that it might be difficult for farmers without a technical background to understand the solution and that this could be a barrier for implementation.

> *"The other farmers, I think they never studied physics or something like that. That would be the barrier for them to understand how the sensors are getting the results"*

He furthermore is a bit hesitant to trust the solution completely himself, as he is only using the recommendations of the app on his test field.

> *"Actually, I'm still not exactly following all the instructions from the app, besides water and temperature and nutrients, basically I follow them ... But I will start also using more instructions and the recommendation from the app about organic fertilisers ... It's organic fertilisers, so it can't be so dangerous.*

Willingness to buy

The farmer says that he will wait until he can see the results of using all recommendations from the solution on his test field. If these results are positive, then he will buy and apply the solution on a larger piece of land.

Summary

Overall, the farmer thinks the solution is easy to use and useful so far. He has not used all features of the app yet and wants to see the results before buying the application and applying it on a larger piece of land.

4. *Use case 2.7 Multi-sensor cow monitoring (dairy)*

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
The multi-sensor cow monitoring system is made up of a small rumen bolus and collar, monitoring various physiological data, and a cloud-based server application to provide accurate information for daily operations.	35 acres	1 year	Owner of a meat farm	Used a collar monitor before for 1,5 year.

The farmer who was interviewed from use case 2.7 mentions that he is the owner of a meat farm of 35 acres and that before using the solution from IoF2020, he had already used neck collars for his cows. This end user is supported by the use case to translate the questions and answers.

Objectives of the end user

The first objective of the farmer is to use the heat detection of the solution to speed up the production period. Furthermore, they aim to detect animal health issues in an earlier stage than the physical systems do. He also wants to optimize the calving period using the calving alerts of the solution.

After using the solution for a while, the farmer formulated a new objective about economic returns. He thinks that selling the animals with the bolus and health history can increase the economic value of the animal.

Ease of use and usefulness

The farmer mentions that the solution is very easy to use and thinks that it is also very easy for others to learn how to use it (e.g. for veterinarians). Furthermore, he states that whenever system fails, he can call somebody involved in the use case to solve the issues. The farmer mentions that the solution provides quite accurate data around heat detection. However, as the system was developed for dairy farming, the alert system is not optimal. He mentions that the use case is working on that. Regarding the calving alert, the farmer indicates that he cannot say anything about that, because he has not yet used it.

> *Translator from use case: "The only issue we have to solve is the water intake alert. It generates too many alerts for him because it is optimized for dairy farming. We are working on it to refine and be able to send alerts only if the cow doesn't drink at all for days, and not only for a few hours."*

"It is a system under development, so there are some fine tunes needed, the farmer cannot rely solely on this system. It is 90% ready. When the system is 100% finalized, it will provide a much better work-life balance. Then the farmer can rely on the system, and spend much less time managing the people on the farm and the animals themselves, as they will be managed by the system."

"If the system is absolutely reliable then the safety feeling for his farm comes into play. This also provides value and better work-life balance and financial value."

Risks and/or challenges according to the user

According to the farmer there are two risks: an animal health risk (bolus) and the risk that the results are not clear from the start as it is a new technology under developing. However, the farmer says he is convinced that the solution works and that the animal health risk is minimal.

Translator from use case: "This is an R&D project, things can happen, but the farmer believes in it and it is more of an opportunity for him than a risk."

Furthermore, the interviewee believes that more and more younger farmers are interested in new technologies and that here lies an opportunity as well. However, he thinks that more promotion is needed to convince younger farmers to use the technologies.

Willingness to buy

The farmer mentions that he had already bought the solution with a discount at the beginning of the project.

Summary

In general, the farmer thinks the solution is very easy to use and that the solution provides useful and accurate data. The solution can still improve on reliability and on its alert system. He already bought the solution at the beginning of the project with a discount.

5. Use case 3.3 Automated olive chain

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
The automated olive chain overhauls the olive chain by realising automated field control, product segmentation, processing and commercialisation of olives and olive oil.	Olive trees, 15 acres	3 years	Owner of the olive farm (48)	Electrical engineering back ground, no further experience

The interviewee that used the solution developed within use case 3.3 is the owner of an olive farm of about 15 acres. He is already using the solution for 3 years and has a background in electrical engineering.

Objectives of the end user

The main objective of the farmer is to automate and optimize the irrigation and gain a better understanding of the watering needs of the olive chart. The other objective is to use the meteorological data for disease prediction.

Ease of use and usefulness

The farmer mentions that the application is straightforward and very easy to use. He has had some problems in the beginning (clogging in electro vaults, cabling issues, etc). However, after setting up correctly the problems have solved. The ease of use of the application could be improved according to the farmer by opening the main screen directly (instead of after pushing a few buttons).

He also states that the solution saves him a lot of effort and that it allows him to concentrate on more important work. He says that it saves him money and time because he does not have to go to the field as often as before, and that the solution gives him more control over his work.

> *"In cases of an adequate size farm and watering I think we should go towards this, it's a pity to not do it. You can have your money back, your investment in a year. I mean just to save the diesel back and forth."*

Risks and/or challenges according to the user

An important risk or drawback that is mentioned by the farmer, is the difficulty to implement the solution in farms with a lot of small fields. He also thinks that automation is a good thing, but that the connection with the field should not be lost leaving it alone to the technology to decide. Furthermore, the interviewee states that farmers can be difficult in adopting new technologies and that it is important to also see other farmers using the solution.

> *"If this solution is adopted by a critical mass, e.g. at least 15 farmers start using the technology, then about 8 % of the farmers will adapt the solution ... Farmers are really cautious because advertisements of technologies promise good results, but this is not always what the farmers experience after implementation of these technologies."*

Willingness to buy

The farmer mentions that he is definitely going to buy the solution at the end of the project.

Summary

The farmer thinks the solution is very easy to use and useful as it saves him money and time. A challenge that he mentions is the ability or willingness of other farms to adopt the solution, because they own a lot of smaller fields or might doubt whether the technology would provide good results.

6. Use case 3.4 Intelligent fruit logistics

Short description	Farm/company type and size	IoT usage	Role interviewees	Prior agri-tech knowledge of the interviewee
Intelligent fruit logistics implement basic traceability to ensure better communication	Logistic provider	N.A.	Employee IOT department & Innovation Coordinator	N.A.

The interviewees for use case 3.4 are an employee from the IoT department and an innovation coordinator. They speak on behalf of the end user and are user of the interface themselves as well. The internal users, the asset managers in the field, have direct contact with the external, end customers of the solution, who are retailers and farmers renting crates. The end customers receives this service and can tell asset managers about their problems or issues. The asset managers are using the software and receive support from the use case in using it. Asset managers are not yet using the solution.

Objectives of the user

The main objectives are to optimize the logistic process using geo-positing and the prevention food losses using temperature tracking.

Ease of use and usefulness

The employee from the IOT department mentions that the interface of the solution is easy to use for them and that the eventual report for the customers is easy to understand, as it is based on the customers' questions and especially made for them. The innovation coordinator adds that using the smart trays gives more control over where the crates are, prevent losing crates and can therefore save a lot of money. The employee from the IOT department also thinks that the solution is very useful for everyone and that using the smart treys can increase the quality control of fruit and vegetables and reduce food waste. However, their focus is now on the geo-positioning rather than the temperature tracking as it is more reliable.

> *Innovation coordinator: "So if a customer says I lose five trays, then it doesn't make sense because if you look at the cost price of the smart tray, it's about 300 euros. Five trays of 3,50 euros, that's not really interesting. You need to have very strong indications and certainty that at a certain spot in the supply chain you have an issue and you can then start using smart trays"*
>
> *Employee IOT department: "Let me put it this way, our reliability on pinpointing a certain location is better. So the end customer is also better able to use that information. That's also a little bit why the focus moved there. But with having this improved, geo-location, the temperature data becomes also more interesting, because then they know exactly where the issue was. And then you see it moves back again to temperature. I think that will take a few years, one year plus."*

The interviewees state that there are also some limitations that can still be improved. One example is the employee from the IoT department mentions is about the network connection: the use case is working with is SigFox, which is not available in all areas which makes it impossible to work with the smart trays.

Risks and challenges according to the user

One of the risks mentioned by the innovation coordinator is the risk of losing smart trays. They are not able to separate the smart trays from the other trays (yet), which can be problematic (see quote below). At the same time, there is another risk of losing the smart tray when the battery of the smart tray runs out, because it is then almost impossible to find it again.

> *Innovation coordinator: "We are not able to retrieve the smart trays, which sounds weird because with smart tray, as you can see where it is. But if you have a warehouse with 20 million green trays and your smart tray is also green, then good luck (finding it).*

Other risks mentioned include the risk of getting too many requests (the demand is higher than the supply at the moment), the high costs price of the crates and that robbery therefore might become an issue in the future and lastly, that people could develop jammers to prevent the sensors from sending information.

Willingness to buy

The IoT department employee mentions that (bigger) customers are willing to pay for the solution.

> *"But we know that the business model would work because the interest in such a smart tray is high enough that a big retailer or big customers are willing to pay. I think we can say it like this."*

Summary

Overall, the interviewees think that he solution is easy to use and very useful, especially for larger customers that have strong indications that there is a logistic problem within the supply chain. They also think that these customers are willing to pay for the solution.

7. Use case 4.1 City farming leafy vegetables

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
The city arming leafy vegetables demonstrates the integration of IoT technologies into the production of high-quality vegetables, leveraging advantages in the production approach	Vertical farm	3 years	Technical project manager, plant specialist & global product manager	N.A.

For this use case, three people were present at the interview. The technical project manager, a plant specialist and the global product manager. The plant specialist is mainly running the trials in their own test station and was mostly answering the questions.

Objectives of the end user

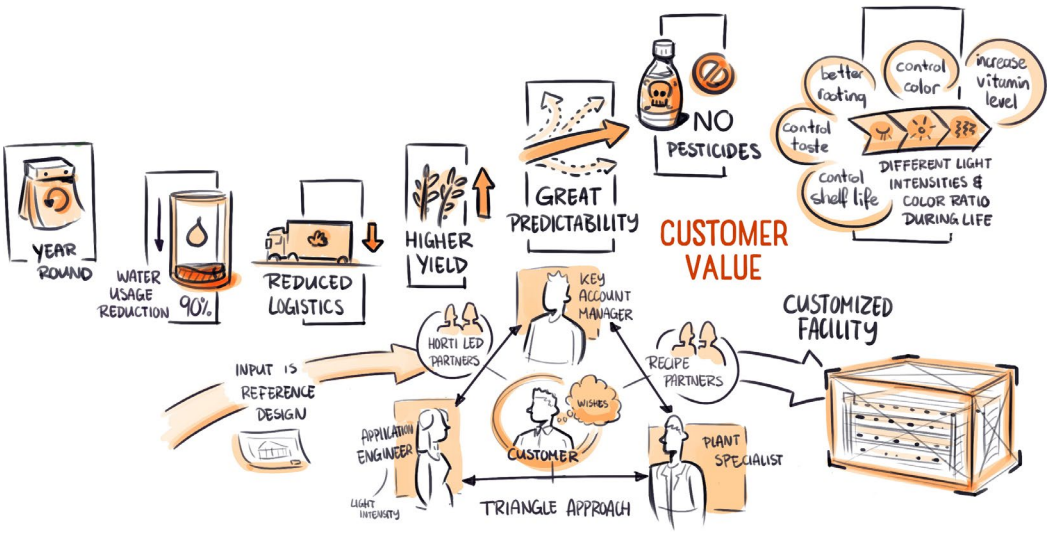
The overall objectives mentioned by the plant specialist were to optimize and control the quality of indoor farming.

Ease of use and usefulness

The plant specialist mentions that the solution is easy to use and user friendly. There is a clear dashboard, the solution is interoperable with other systems and it is a calibrated system which is

automatically running according to the specified (lighting) settings of the user. However, results still need to be analysed manually and ideally this would be automated in the end. Furthermore, the plant specialist mentions that in terms of usefulness, using the solution saves time and makes researching the effect of different types of lighting on plant characteristics a lot easier compared to other systems.

> *"It's accessible from everywhere you are. So you don't have to be in the farm necessarily to see what's going on. So that makes it much more easy. And it saves you a lot more time. I would say you would spend five minutes a day, to check the climate, and see how the plants are doing."*



Risks and/or challenges

One challenge mentioned by the plant specialist is the cost price of the solution. The solution could be rather costly for smaller farms. Developing a simpler version of the solution for smaller farms could be an option.

> *"The system has a certain price. A cost price, let's say. Because there are so many elements inside and it's built to be able to go with big farms, but it's a lot of big farm start as a small farm. In a small farm, this is a rather costly solution."*

Another challenge might be that there is sometimes need for a plant specialist to explain certain (growth) issues that may pop up.

Willingness to buy

During this interview this was not discussed.

Summary

Overall, the plant specialist thinks the solution is very useful and easy to use. The solution could however be improved by automating some of the analyses of the results. The solution is built for larger farms and might be too expensive for smaller farms in its current form.

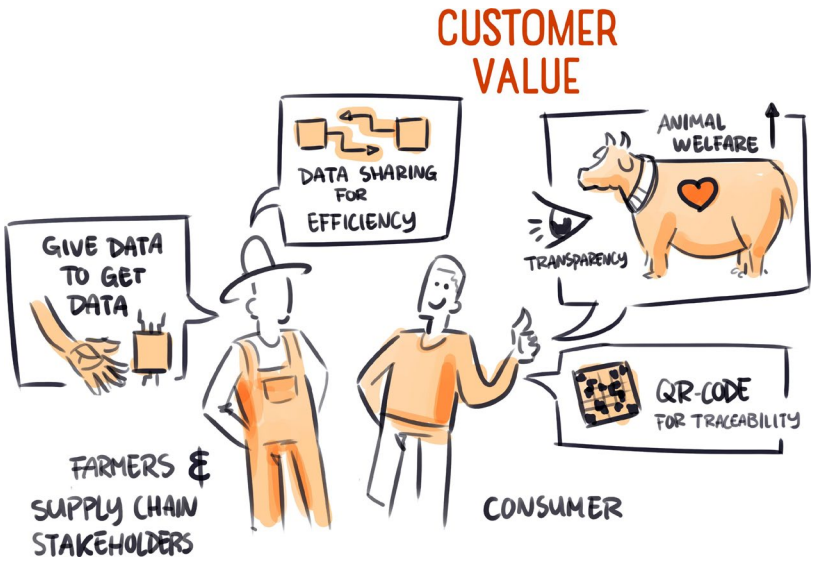
8. Use case 5.4 Decision-making optimisation in the beef supply chain

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
Current traceability systems collect few data from every segment of the supply chain, mainly to assure food safety to consumers.	Meat farm, 220 hectares	1,5 year	Meat farmer and son	No

From use case 5.4, a farmer and his son were interviewed. The farmer owns a meat farm of 220 hectares and said that he had no experience with prior technologies. The son was translating the answers for his father.

Objectives of the user

The objective of the farmer was to increase his knowledge about what was happening on the farm by using the location of the animals (calving alert, disease prevention and notifications when the animal is outside the field) and therefore being able to detect problems at an early stage.



The farmer mentioned that he had two other objectives for the future: to use the data of the application to improve decision making on the farm (right now he did not have enough data) and to use the weighting option of the solution for the calves, which was not working at the moment.

Ease of use and usefulness

Overall, the farmer thought the solution was very easy to use and easy to understand. He mentioned that the solution was intuitive. He mentioned that is did take some time to put the collars on the animals, and that this can be difficult. Furthermore, the farmer mentions that some of the collars broke, but that he received new ones.

> *"But we have to be honest that putting all the neck laces on the neck of the cows. It's difficult if you don't have the structure in your farm. You have to have good shoots and a restrainer to hold the animals where you are putting the neck lace in their necks. So it's true that if you don't have good structure in your farm. It's going to be impossible to put the neck laces on the cows. We are lucky because well, we have put money in the farm and we have very good shoots and restrainer to hold the animal properly."*

The farmer says that the solution is useful and that the objectives were met. The solution improves their work, increases control over the work and gives important information on the farm.

> *"The solution gives us the opportunity to all the work of observation we do in the land, looking for the animal, is possible with your phone. In the night and in the mornings if you are abroad if*

you are travelling or wherever you can control, it's not the same than being of course looking the animals that you can control where the animals are, and, you know, improve your work. From everywhere. You don't have to be in the land."

Risks and challenges according to the user

One of the risks or challenges that was mentioned by the user was that some farms might be sceptical towards the technologies. The farmer mentioned that they heard about similar technologies elsewhere, and that they failed. Farmers might therefore be hesitant using the technologies.

"So the first time when Koba offered us to try the neck laces we were a little hesitant, we didn't want to try them because we knew that in the other case they hadn't worked very well. But at the end, they told us that they were developing them. And they were, you know, putting more money and trying and trying their best to develop them as it has to be. And we finally tried, and we are really, really, really happy because the changes have been amazing."

Willingness to buy solution

The farmer mentions that they will buy collars, but that the amount of collars they will buy depends on the price. They will probably not buy a collar for all the animals, but will certainly buy collars for the bulls and the pregnant cows.

Summary

Overall, the farmer thinks the solution intuitive, easy to use and useful so far. He cannot judge all functionalities of the solution, as has not yet tried all of them. One important challenge for the future mentioned by the farmer is that other farmers might be hesitant adopting new technologies.

9. Use case 5.5 Feed supply chain management

Short description	Farm/company type and size	IoT usage	Role interviewee	Prior agri-tech knowledge of the interviewee
This use case develops an integral feedstock management system to optimise the entire supply chain.	Manufacturer	12 months	- Logistics and project manager - Member of sales support team	No

The end user from use case 5.5 was a member of the sales support team. She and her manager were both present during the interview.

Objectives of the end user

The main objectives of the manager are about cost effectiveness and quality control. She wants to make sure the sales support team puts in the correct orders, (re)structure the production and transport system so it becomes more efficient and thereby increasing customer service.

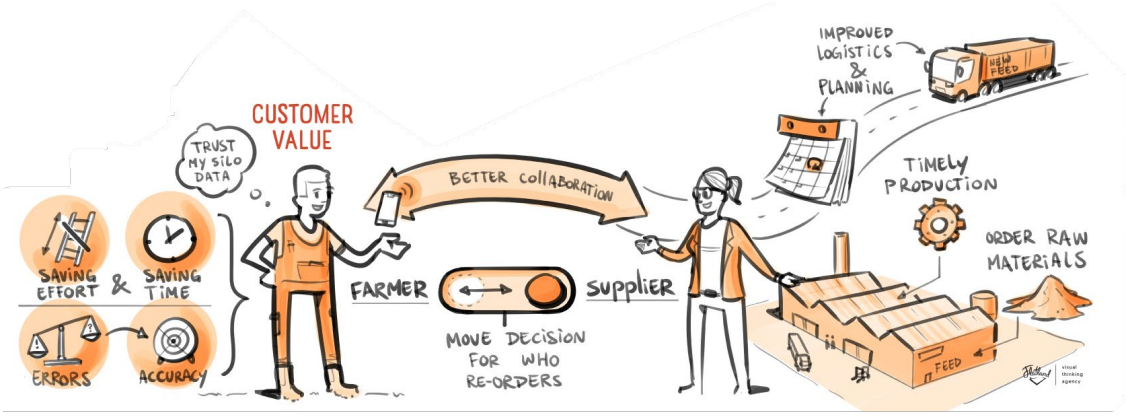
For the end user, the main objective is to become more efficient (save time) in placing orders for the customers.

Ease of use and usefulness

Overall, the manager think the system is easy to use and user friendly. The end user agrees that the system is very easy to use, but that they could make the solution more user friendly by adding alerts when customers need a new order, providing more guidance in the app by showing your last activity, adding last order boxes so you can easily repeat an order and by making the solution more interoperable with other systems they are using.

The member of the sales support team mentions that for her using the solution saves a lot of time because she can accomplish her tasks more quickly than before and that she thinks the solution is reliable. The manager also indicated that using the solution enables more accurate decision making and saves production time and costs, which makes the solution cost-effective.

> *Manager: "It reduces call time, it reduces production time, if we can make things in bigger amounts, we get better production runs. And so yes, it seemed just to be the ideal of technology that we needed."*



Risks and/or challenges

Before using the solution, the manager saw two risks. First of all, the solution could have been unreliable in terms of information, which could damage their reputation. Furthermore, she was concerned that farmers would not want to cooperate which was necessary for using the solution.

At first, the manager also had some reservations about the solution and the costs of the solution. Even though she is very pleased with how the solution is working, she is not sure whether it would be cost efficient for the smaller farms.

> *"We haven't really tried it on many smaller farms, and whether that would be actually cost efficient with the smaller farms, I'm not 100% sure yet. I wouldn't think it would, it would have to be the bigger farms we used it on."*

Willingness to buy

They already bought the solution for the bigger farms. For the smaller farms, it would really depend on the eventual costs of the solution.

> *"And I don't think it's a chance that we've looked back and said, "we shouldn't have done it". I think we've actually improved."*

> *"That's the only thing that I would say. It's a marvellous system, but for us to take it up completely, would really depend on the cost for our smaller farms."*

Summary

Although both interviewees were a bit sceptical about the solution in the beginning, they do think the solution improved their business and saves them a lot of time. They think the system is generally easy to use, although the end user mentioned some improvements to make the solution more user friendly. They already bought the system for their larger customers and are not sure whether it would be cost-effective for the smaller farms.

5.3 SUMMARY OF THE INTERVIEW RESULTS

Using the descriptive results of each interview and the coding of the interviews, the overall results of the interviews are summarized below.

Usefulness

Figure 13 presents a network analysis of the coding of the interviews to give an overview of the pre-defined general codes used for usefulness in Atlas.ti. Additional codes were used to give meaning to statements made by several interviewees, as described below.

All use cases mentioned at least once that the solution is *useful in their jobs* and *addresses job-related needs*. Eight out of nine users specifically indicated the solution is *cost-effective* and *saves time*. Seven end users indicated that the solution provides *more control* over their work and five out of nine end users mentioned that the solution increases the speed of *accomplishing tasks,* increases *efficiency* and saves *money*. On the other hand, also five out of nine end users indicated that it sometimes *takes time* to interact with the solution, that the solution needs *further developing* and provided *improvement suggestions*. Four out of nine users also mentioned that the solution *reduces their time spend on unproductive activities* and that they experienced *malfunctioning* of the solution.

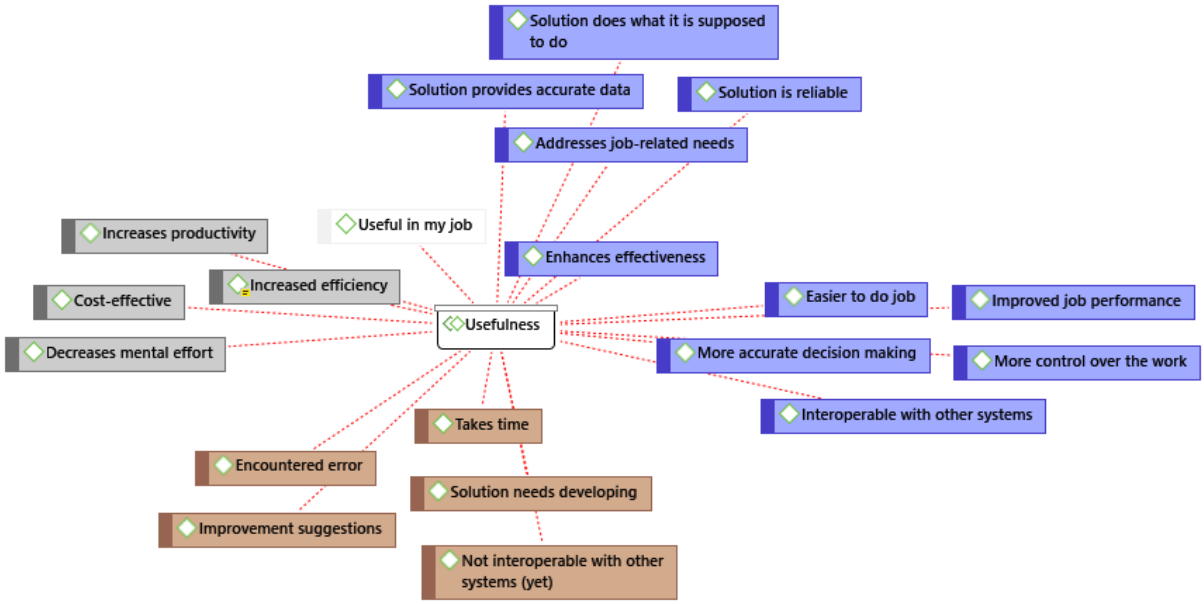


Figure 13: network analysis of usefulness

Perceived economic value, cost and productivity

All interviews mentioned at least once (but often more times) that the solution saves time and/or resources. Three interviewees said they would definitely buy the solution (UC 1.8, 3.3, 5.4) , two stated that they already bought the solution and were happy they did (UC 2.7, 5.5) and another interviewee stated he did not have to buy the solution because it was for free (UC 1.1). One interviewee was not yet sure whether he wanted to buy the solution, he first needed more input in the results (UC 1.6). The interviewees from use case 4.1 think the business model works and that customers are willing to pay for their solution.

Ease of use

In *Figure 14* a network analysis of the coding of the interviews is presented to give an overview of the general codes used for ease of use in Atlas.ti. Specific codes that were mentioned by several interviewees are described below.

All interviewees mentioned that the solution is *easy to use* at least once in the interview. Furthermore, four interviewees mentioned at least once (but often more times) that the solution is *easy to understand* and that *support service and guarantees* were provided in the case of malfunctioning. Three interviewees also mentioned that the technology was *straightforward or intuitive*. Three interviewees mentioned that using the solution could lead to *confusion or frustration*. For one user this confusion was already solved in the beginning, for the other users it was not (yet) solved.

Some interviewees also mentioned improvement suggestions for ease of use, which were quite specific for each use case. Two interviewees mentioned that the solution would be easier to use when it would be interoperable with other systems. Others mentioned the functionalities within the application, to get alerts or notifications after certain incidents.

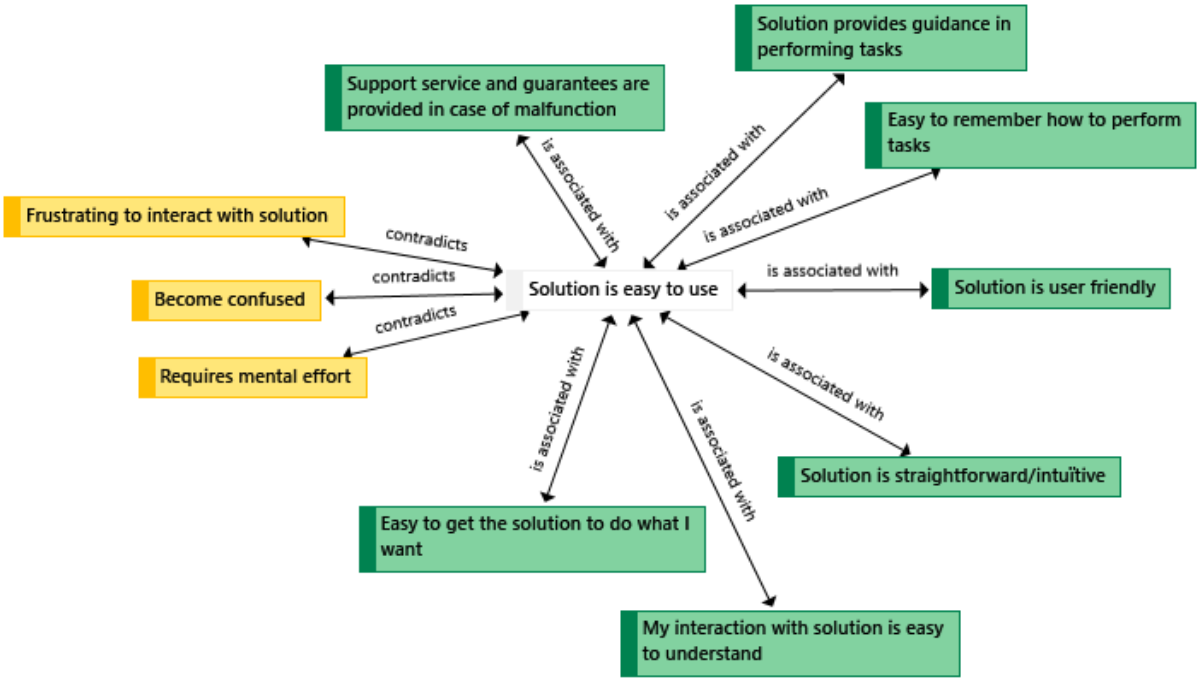


Figure 14: network analysis of ease of use

Knowledge transfer

Only one interviewee highlighted the importance of knowledge transfer. This interviewee believed that more and more young farmers are interested in new technologies, but that more promotion is needed to convince them.

Risks and challenges

During three interviews the challenge of convincing other farmers to adopt the technologies was mentioned. The interviewees thought other farmers can be sceptical towards new technologies, hesitant to adopt them and/or do not trust the effectiveness of new technologies. One interviewee specifically mentioned age or generation of the farmer as a suppressive factor for adopting new technologies.

During five interviews, the interviewees mentioned the risk of the solution not being as interesting for smaller farmers than for larger farms. Using the solution might not be cost-effective for smaller farms or companies, because investment costs of the solution are larger than what they would gain.

6 CONCLUSIONS AND RECOMMENDATIONS

The first goal of this report was to bring insights in user acceptance testing support in IoF2020 use cases to understand and improve user acceptance. The second goal was to find the key experiences, feedback and issues in using IoT smart farming solutions at the start-up phase in the context of IoF2020.

This section concludes the main findings of quantitative and qualitative study results (6.1), discusses lessons learned about user acceptance testing (6.2), and provides recommendations for the use cases, their stakeholders and policy makers (6.3).

6.1 USER ACCEPTANCE IN IOF2020

This section concludes findings from the research on user acceptance in IoF2020 use cases. The user acceptance has been considered as a function of usefulness, ease of use, perceived economic value, cost and productivity, knowledge transfer, facilitating conditions and usage.

Usefulness

IoT solutions in IoF2020 use cases are generally perceived positively by the end users, i.e. farmers and companies. The benefits of the solutions are more evident when comparing with current farming practices. These benefits, such as reduced working time, which is an essential issue of the current workload in the farming, is one of the most important benefits. End users also indicate that the solution provides more control over their work and increases the speed of accomplishing tasks with that, the efficiency.

Ease of use

The results of the survey and interviews show that IoT solutions in IoF2020 use cases are easy to understand and use. However, the results also show that sometimes special (ICT) expertise is needed in using the IoT solution. The fact that respondents vary in their opinion on the need of special data reflects the differences in product development maturity level of the use cases. We might argue that the more mature the product is (late MVP stage), the less special expertise it might require and the more user friendly the product is. However, we have not done the cross check analysis to confirm the correlation between MVP stage and need of special expertise. Nevertheless, the interview results confirm that the end users needed and have received training when using the IoT solutions. Additionally, end users perceive installation of IoT devices as easy and understand the design of the solution.

Perceived economic value, cost and productivity

The results indicate that the end users experience an increase of productivity and profit and a reduction of cost. IoT solutions in IoF2020 use cases enable a quick reaction to changing circumstances, allow to control the production efficiently by having access to real-time and accurate data. By doing so, end users can make better decisions, which helps reduce costs. Most of the interviewed end users reported an increase of yield and better quality after using the IoT solution. Additionally, as the results reveal, IoT application makes the workflow logical and fast.

Knowledge transfer

From the results, we can conclude that experience of farmers about digital solutions is an important source for other farmers. This is in line with the theory provided by Ramirez et al. (2010). Considering

the thought that farmers may not have been pioneers in technology innovation but have rather been followers or late adopters, the transfer of learnings, knowledge and experience among farmers is crucial in IoT adoption. Traditional farmers (i.e. primary producers) seem to prefer learning from their peers rather than from e.g. other industries. This, however, might not be true in agri-food processing companies and other supply chain actors along the food chain, as they are using modern technologies (i.e. production robot hands, conveyor belts, and digital systems) more than the primary producers.

Facilitating conditions

The results show several crucial conditions that are needed to facilitate adoption of IoT solutions by the IoF2020 use cases (*Figure 8*). The most important facilitating conditions are:

- Connection between data receiver and data transmitter
- Presence of internet connection and availability of WiFi,
- GSM and mobile network coverage,
- Guarantees of security.

Evidently, internet of things need internet connection to function. Therefore, (high speed) connectivity is needed to enable IoT especially in rural farming areas.

Other issues highlighted by the end user are battery life of hardware, robustness of the hardware and flexible telecommunication plans.

Actual usage of IoT

The results show that the majority of the respondents have actually applied and currently use the IoT solutions. The others were either testing the solution, planning to apply within a year, or express their interest. Considering the selection of the sample, i.e. end users that are linked to IoF2020 use cases, this result is somewhat unexpected and might indicate that not all use cases have managed to reach the appropriate product readiness level to test it with the end user. Although we have not tested the link between no actual use and product readiness level of the use cases, as this is out of the scope of this report, this could be an interesting topic for a further research.

Actual IoT usage is related to confidence. As the results indicate, most of the end users are confident about using the digital solution. Having confidence in the solution may also be a driver for the intention to use technology (Pierpaoli et al., 2013). Being confident about using the solution is related to the solution being easy to understand, providing more accurate decision making and clear benefits.

To conclude, this report provides insights in user acceptance testing support in IoF2020 use cases by describing the activities and research performed to understand and improve user acceptance. Key experiences and feedback were gathered through questionnaires and interviews allowing for us to describe usefulness, ease of use and issues in using IoT smart farming solutions at the start-up phase in the context of IoF2020.

6.2 UAT LESSONS LEARNED

During user acceptance testing several important lessons were learned that should be taken into account in future projects.

First of all, the promotion of user acceptance should have happened earlier on in the project. As it is an important part of project and impacts the eventual usage of the developed technologies later on, it should have been introduced in the first phase of product development.

The Minimal Viable Product loop could have been optimized for those use cases that had just one MVP cycle, finalizing a first product only at the end of year three or four.

The questionnaire platform stated that 53% of users fill in their questionnaire via their smartphone, so having the questionnaire mobile ready is key for user acceptance testing.

Some of the farmers did not feel comfortable speaking English, so the questionnaire had to be translated for them, which made filling in the questionnaire more time consuming. For the interviews the language barrier might have led to a lower response rate.

The questionnaire itself was quite long and did not include questions on prior agri-tech knowledge and if the user is willing to pay, which is what we asked for during the interviews. Most of all, it is key to help stimulate the dialogue between users and solution providers.

We expect that the support use cases received from WP4 contributed to achieving positive UAT results and a competitive edge in the market. The evaluation of WP4 activities and lessons learned could provide more information on this. Deliverable 4.5 *Overall lessons learned regarding business model* (to be finalized in March, 2021) will provide insights into the use case characteristics that play a role in their business models.

The final lesson learned concerned the diversity of the products and end users of the use cases. Because of the diversity, it was hard to create a more 'abstract' survey that fitted all of them. Better test results could have been used at the use case level if more use cases would have created their own survey or UAT process, although some of the use cases did.

6.3 RECOMMENDATIONS

This section provides the main recommendation to three targeted stakeholder groups: IoF2020 use cases and similar start-ups IoT initiatives, current and upcoming IoT projects and policy makers.

6.3.1 Recommendations for IoF2020 Use cases and similar IoT initiatives

In general, usefulness and ease of use are evident when adopting IoT solutions in agri-food sector. The usefulness and ease of use of technology usually leads to actual use. Even though the quantitative study did not provide significant evidence due to empty fields in the data, the in-depth interviews confirmed that usefulness and ease of use stimulate IoT adoption.

This report suggests that usefulness of IoT solutions translates mainly in terms of delivery of fast results, accurate decision making and economic benefits. Whereas, ease of use is considered mainly in terms of product installation, design and availability of support services in case of malfunction. Usefulness and ease of use are related to the confidence to use IoT. Therefore, we recommend IoF2020 use cases, and similar start-up initiatives to consider these factors when developing and validating their product at the end users.

Price quality ratio could be a hurdle for farmers, which could support the idea that starters can focus on low-cost technology to achieve higher adoption. However, solutions must also be useful enough to provide benefits to the farmer, either through an improvement, by doing something easier or cheaper

than before, or an innovation, something that was not previously done because of financial constraints or an incongruence between the technology and farmer's skills (Pierpaoli et al., 2013).

Interestingly, the age of the farmers as function to technology adoption has been widely discussed in the literature and has been mentioned by several interviewees. Although this study does not provide hard evidence of significant correlation between the age of the farmer and the actual usage of IoT, we argue that collaboration with relatively younger farmers with a less conventional attitude has impact on the acceptance of an IoT solution based on the interview findings. Therefore, we recommend engaging younger farmers in such initiatives to showcase best practices and match them with less experienced or older farmers during development.

The rapid development of technology and technology adoption create a body of knowledge and experience that are essential for farmers, who are risk averse and conservative in changing farming practices. Nevertheless, the more successful IoT solutions with beneficial outcomes are adopted in agri-food, the more eager could farmers become in following innovation, also to maintain their competitive position. Our expectation therefore is that the user acceptance level of IoT solutions will increase with years. Therefore, we recommend studying the user's experience regularly, and use their feedback in further developing the solutions.

Next, the unique character (and at the same time the challenge) of IoF2020 use cases is the tremendous difference between the end users (i.e. farmers) and solution developers and providers (i.e. use case partners). Farmers are generally not known to be the early adopters of high tech applications and most technology developers have hardly any farming experience. Bringing these two completely different worlds together requires brokerage and communication skills. We recommend use cases to hire specialists that have the capabilities to understand farmers and experience in high tech solutions and collaborating with engineers.

Finally, to stimulate IoT adoption, use cases need to cope with the facilitating issues, such as:

- Improve connectivity (in rural areas)
- Improve battery life of hardware (sensors etc.)
- Improve robustness of the hardware
- Provide flexible connection telecom plans.

6.3.2 Current and upcoming IoT projects

WP4 team has developed several methods and tools to support IoF2020 use cases in assessing the user acceptance level, i.e. survey, feedback sessions, individual use case support calls, and interviews along the years of IoF2020 project. These tools are generic and can serve as inspiration. They contain the main and the most relevant elements of user acceptance testing and are currently being transferred to the SmartAgriHubs project and the survey has even been made available in the form of an agri-food questionnaire template (as in *Appendix 6: UAT questionnaire*) supported by the ReachOut platform (https://www.reachout-project.eu). To address the specific features of IoT solution, the questionnaire can be adjusted and customized with ReachOut, free of charge for other EU projects, as was done by UC3.2 and UC3.6 in IoF2020

Another recommendation is related to the language of the tools. Unfortunately, not all farmers from non-English speaking countries speak English, and very often they prefer local language. We recommend using professional translation services and sending locals to the fields for data collection.

6.3.3 Policy

Although this report focuses on end users testing from a use case perspective, some recommendations can be extracted for the policy makers.

The evidence shows that IoT solutions are useful and often easy to use, beneficial for the farmers, but the actual usage still has enormous potential to grow. Since farming is not particularly known for its innovativeness and high tech adoption, a radical change in the sector is needed. The application of professional user acceptance testing in every research project that intends to bring products or solution to the market is therefore key.

Creating a network with high-tech farming examples can improve the confidence and support the dissemination of knowledge. Also creating so-called brokered network of experts that have farming experience, understand technology and believe in high tech benefits is essential in bridging the gap between the partners engaged in developing IoT solutions.

Finally, the IoF2020 findings show that the more mature the IoT solution is, the easier users accept it. Eventually, IoF2020 end users take risks when adopting revolutionary technologies, because they have to live and run their business in an agri-food sector that is intertwined with farming income and food safety issues.

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APPENDIX 1: UAT STATUS PER USE CASE

	UC	UAT questionnaire	Feedback Session (short q.)	Interview
Arable	1.1 Within-field management zoning	yes	yes	yes
	1.2 Precision Crop Management		yes	
	1.3 Soya Protein Management	yes	yes	
	1.4 Farm Machine interoperability	yes (not a final product yet)	yes	yes
	1.5 Potato Data Processing Exchange	yes	yes	
	1.6 Data-Driven Potato Production	yes	yes	yes
	1.7 Traceability for food and feed logistics	yes	yes	not a good time for testing
	1.8 Solar powered field sensors		yes	asked to fill in questionnaire
	1.9 Within-field management zoning		yes	
Dairy	2.1 Crazing Cow Monitor	yes		
	2.2 Happy Cow	yes		yes
	2.3 Herdsman +	yes		
	2.4 Remote Milk Quality			contacted, not planned yet
	2.5 Early lameness detection through machine learning	yes		
	2.6 Precision mineral supplementation			
	2.7 Multi-sensor cow monitoring	yes		yes
Fruits	3.1 Fresh table grapes chain	yes	yes	
	3.2 Big wine optimization	yes	yes	
	3.3 Automated olive chain	yes	yes	yes
	3.4 Intelligent Fruit Logistics	yes	yes	yes
	3.5 Smart orchard spray application	yes	yes	
	3.6 Beverage integrity tracking	yes	yes	
Vegetables	4.1 City farming leafy vegetables	yes	yes	yes
	4.2 Chain-Integrated Greenhouse Production		yes	
	4.3 Added value weeding data	yes	yes	
	4.4 Enhanced quality certification system	yes	yes	
	4.5 Digital ecosystem utilisation	yes	yes	
Meat	5.1 pig farm management	yes	yes	not a good time for testing
	5.2 Poultry chain management	yes	yes	
	5.3 Meat transparency and traceability		yes	
	5.4 Decision-making optimisation in beef supply chain	yes	yes	yes
	5.5 Feed supply chain management	yes	yes	
	5.6 Interoperable pig tracking	yes	yes	

APPENDIX 2: CORRELATION OVERVIEW

An overview of constructs from literature, interview questions and hypotheses.

Construct	Independent variable	Dependent variable	Hypothesis
		Intention to use	
Usefulness	Usefulness of the product/solution (Q14 + Q49)	We plan to apply within a year We are interested, but have no specific plans No, but maybe later Not at all (Q12) I am confident about using the digital solution. (Q22 + Q51)	The usefulness of the solution relates to the intention to use the solution. The usefulness of the solution relates to user confidence.
Performance Expectancy / Technical quality	Technical quality and infrastructure (Q20 + Q50)		Farm infrastructure and interoperability relate to the intention to use the solution. Farm infrastructure and interoperability relates to user confidence.
Ease of use	Q17		The ease of use of the solution relates to the intention to use. The ease of use of the solution relates to user confidence.
Knowledge	It is important for me to know the experience of fellow farmers about digital solutions. (Q22 + Q51)		Knowing about experience by fellow farmers relates to the intention to use the solution. Knowing about experience by fellow farmers relates to user confidence.
		Usage	
Perceived economic value Productivity Profit	Cost-efficiency and feasibility Using the product/solution of our use case can increase my farms productivity. Using the product/solution of our use case can increase my profits. (Q23 + 52)	Usage Do you already use the product/solution of our use case? Yes, already applied in my farm or company (Q12)	Increased productivity and profit relate to usage of the solution.
Facilitating conditions	Which of the following issues hinder the product/solution of our use case applications in your farm or company (Q21)		Facilitating conditions relates to usage of the solution.

APPENDIX 3: CORRELATION ANALYSIS

Test statistic

As all variables are multinomial, the Chi-square statistic for independence is considered to be a suitable test to analyse group differences. The Chi-square statistic is a distribution free test. In addition, it does not require equality of variances among the different categories (McHugh, 2012). However, a prerequisite for the Chi-square test is that all expected group frequencies are five or above. As the questionnaire data contained many blank answers, this prerequisite was not met.

One solution is to combine several categories to increase the number of observations per group ("Chi-square test of independence in R | by Antoine Soetewey | Towards Data Science," n.d.). To apply this on the questionnaire data, the 5 point Likert scale questions were transformed to a 2 point scale; agree (strongly agree and agree) and disagree (neutral, disagree and strongly disagree). But also this transformation did not result in sufficient group frequencies.

Another solution is to use Fisher's exact test ("Chi-square test of independence in R | by Antoine Soetewey | Towards Data Science," n.d.). This nonparametric test does not demand a lower bound on group frequencies. Although Fisher's exact test is designed for dichotomous variables, it can be applied to multinomial data as well ("Alternatives of Fisher's exact test for more than 2 groups?," n.d.).

Calculating effect sizes

Fisher's exact test only reports on statistical significance, which is the likelihood that the differences between groups are due to sampling. In order to describe the strength of the relationship between groups it is necessary to make use of other measures such as calculating effect sizes (Coe, 2002).

The most common measures to calculate effect sizes for nonparametric and ordinal data are Spearman's rho, Goodman-Kruskal's gamma, Kendall's tau and Somers' d. Göktaş and Öznur İşçi (2011) evaluated the different outcomes of the measures by simulation. Results showed gamma came closest to the expected association for lower dimension tables, while rho performed better for higher dimension tables. Tau and d presented relatively poor results (Göktaş & İşçi, 2011).

As the questionnaire data has a limited number of categories per question it was decided to use Goodman-Kruskal's gamma to calculate effect sizes. The coefficient's range is limited from -1 up to 1, whereby 0 indicates there is no association. Values of -1 and 1 indicate a perfect negative and positive monotonic relationship respectively. In case of a positive association, variables change in the same direction ("Goodman and Kruskal's gamma using SPSS Statistics | A How-To Statistical Guide by Laerd Statistics," n.d.).

There exist rules of thumb to qualify effect sizes which were firstly introduced by Jacob Cohen. Commonly used benchmarks are small (.1 - .3), medium (.3 - .5) and large (≥ .5) ("Thresholds for interpreting effect sizes," n.d.). However, these divisions are quite trivial. Small effect sizes can have relevant influence, while large effect sizes could be due to method variance or specification errors (Trusty, Thompson, & Petrocelli, 2004). To avoid such interpretation issues in this research, effect sizes were used to rank associations rather than qualifying them.

Correlation analysis results

Construct 1	Question 1	Construct 2	Question 2	Fisher P-value	Significant	Gamma
Application	Experience of fellow farmers	Application	Confident about usage	0.396	No	NA
Application	Experience of fellow farmers	Usefulness	Usage of solution	0.548	No	NA
Application	Confident about usage	Usefulness	Usage of solution	0.810	No	NA
Cost-efficiency	Increases farm productivity	Usefulness	Usage of solution	0.499	No	NA
Cost-efficiency	Increases profit	Usefulness	Usage of solution	0.981	No	NA
Ease of use	Easy to install	Application	Confident about usage	0.001	Yes	0.436
Ease of use	Easy to understand	Application	Confident about usage	0.000	Yes	0.640
Ease of use	Delivers results fast	Application	Confident about usage	0.002	Yes	0.451
Ease of use	Access on mobile device	Application	Confident about usage	0.053	No	NA
Ease of use	Needs special expertise	Application	Confident about usage	0.083	No	NA
Ease of use	Easy to use	Application	Confident about usage	0.006	Yes	0.483
Ease of use	Support service	Application	Confident about usage	0.008	Yes	0.541
Ease of use	Easy to install	Usefulness	Usage of solution	0.535	No	NA
Ease of use	Easy to understand	Usefulness	Usage of solution	0.329	No	NA
Ease of use	Delivers results fast	Usefulness	Usage of solution	0.009	Yes	0.546
Ease of use	Access on mobile device	Usefulness	Usage of solution	0.263	No	NA
Ease of use	Needs special expertise	Usefulness	Usage of solution	0.869	No	NA
Ease of use	Easy to use	Usefulness	Usage of solution	0.421	No	NA
Ease of use	Support service	Usefulness	Usage of solution	0.942	No	NA

Infrastructure	Infrastructure present to install	Application	Confident about usage	0.027	Yes	0.689
Infrastructure	Interoperable with other solutions	Application	Confident about usage	0.625	No	NA
Infrastructure	Infrastructure present to install	Usefulness	Usage of solution	0.036	Yes	-0.422
Infrastructure	Interoperable with other solutions	Usefulness	Usage of solution	0.031	Yes	-0.067
Usefulness	Benefit is clear	Application	Confident about usage	0.016	Yes	0.718
Usefulness	Reduces working time	Application	Confident about usage	0.700	No	NA
Usefulness	More accurate decision making	Application	Confident about usage	0.042	Yes	0.437
Usefulness	Fosters public acceptance	Application	Confident about usage	0.687	No	NA
Usefulness	Contributes to realizing societal goals	Application	Confident about usage	0.226	No	NA
Usefulness	More benefits than current practice	Application	Confident about usage	0.197	No	NA
Usefulness	Benefit is clear	Usefulness	Usage of solution	0.307	No	NA
Usefulness	Reduces working time	Usefulness	Usage of solution	0.744	No	NA
Usefulness	More accurate decision making	Usefulness	Usage of solution	0.258	No	NA
Usefulness	Fosters public acceptance	Usefulness	Usage of solution	0.257	No	NA
Usefulness	Contributes to realizing societal goals	Usefulness	Usage of solution	0.570	No	NA
Usefulness	More benefits than current practice	Usefulness	Usage of solution	0.250	No	NA

APPENDIX 4: UAT RATING

Use case	Rating	Rounded up rating
1.1	3.71	4 (3.91)
1.1	4.00	
1.1	4.00	
1.3	4.76	4.5 (4.35)
1.3	3.45	
1.3	4.83	
1.5	3.87	4
1.6	4.50	4.5
1.7	3.95	4
2.1	4.05	4
2.2	3.85	4 (4.1)
2.2	4.35	
2.7	4.21	4 (3.71)
2.7	3.43	
2.7	3.00	
2.7	4.21	
3.1	4.12	4 (4.02)
3.1	3.99	
3.1	4.09	
3.1	3.57	

Use case	Rating	Rounded up rating
3.1	4.37	
3.1	3.97	
3.2	4.65	4.5 (4.35)
3.2	4.14	
3.2	4.29	
3.2	4.31	
3.3	3.52	4 (3.86)
3.3	3.86	
3.3	3.71	
3.3	4.34	
3.4	4.30	4(3.94)
3.4	4.14	
3.4	3.81	
3.4	3.50	
3.5	4.29	4.5
4.1	3.55	4 (3.98)
4.1	3.38	
4.1	3.84	
4.1	3.71	
4.1	3.93	

Use case	Rating	Rounded up rating
4.1	5.00	
4.1	5.00	
4.1	4.43	
4.1	4.00	
4.1	3.00	
4.3	3.29	3.5 (3.52)
4.3	3.76	
4.4	2.57	2.5
4.5	4.26	3.5 (3.62)
4.5	4.00	
4.5	3.36	
4.5	3.68	
4.5	3.43	
4.5	3.45	
4.5	3.20	
5.1	3.60	3.5 (3.66)
5.1	3.30	
5.1	3.79	
5.1	3.30	
5.1	3.69	

Use case	Rating	Rounded up rating
5.1	4.30	
5.2	3.50	3.5 (3.54)
5.2	3.57	
5.4	4.43	4.5
5.5	3.65	4.5 (4.32)
5.5	5.00	
5.6	4.00	3.5 (3.74)
5.6	4.14	
5.6	3.57	
5.6	3.23	

APPENDIX 4: USE CASE INTERVIEWS

Table 13: full description of the interviewees and use cases

	Use case	Short use case description	Farm/company type and size	Role interviewee(s)	IoT usage	Prior agri-tech knowledge
1	1.1 Within field management zoning	This use case seeks to develop specific IoT devices for acquisition of soil, crop and climate data in production and storage of key arable and vegetable crops	Arable farm 600 acres	Owner of the farm	3 years	Bachelor in agriculture, lot of experience in using new technologies (precision agriculture)
2	1.6: Data driven potato production	An innovative, market-ready smart farming solution supports irrigation, pest management and fertilisation.	Arable farm 300 hectares	Quality controller of potato farm	<1 year	Bachelor in agriculture and technical engineering
3	1.8 Solar-powered field sensors	Solar-powered sensors bring a soil laboratory to the fields and allows end users to monitor and treat their crops in real time.	Arable (test)farm, 1 hectare	Owner of the farm	<1 year	Bachelor in physics, traditional farming technologies (tractor, water pumps)
4	2.7: Multi-sensor cow monitoring	The multi-sensor cow monitoring system is made up of a small rumen bolus and collar, monitoring various physiological data, and a cloud-based server application to provide accurate information for daily operations.	35 acres	Owner of a meat farm	1 year	Used a collar monitor before for 1,5 year.
5	3.3 Automated olive chain	The automated olive chain overhauls the olive chain by realising automated field control, product segmentation, processing and commercialisation of olives and olive oil.	Olive trees, 15 acres	Owner of the olive farm (48)	3 years	Electrical engineering background, no further experience
6	3.4: Intelligent fruit logistics	Intelligent fruit logistics implement basic traceability to ensure better communication	Logistic provider	R&D worker & Innovation Coordinator	N.a.	N.a.
7	4.1 City farming leavy vegetables	The city arming leavy vegetables demonstrates the integration of IoT technologies into the production of high-quality vegetables, leveraging advantages inthe production approach	Vertical farm	Technical project manager, plant specialist & global product manager	3 years	N.a.
8	5.4: Decision-making optimisation in beef supply chain	Current traceability systems collect few data from every segment of the supply chain, mainly to assure food safety to consumers.	Meat farm, 220 hectares	Meat farmer and son	1,5 year	No
9	5.5 Feed supply chain management	This use case develops an integral feedstock management system to optimise the entire supply chain.	Manufacturer	- Logistics and project manager - Sales support team	12 months	No

APPENDIX 5: OVERVIEW INTERVIEW RESULTS

Table 14: summary of interview results

Use case	Objectives	Training	Ease of use	Usefulness	Risks/challenges	User acceptance scoring	Buy solution?
1.1 Within-field management zoning	*Efficiency* ● Creating variable rate map in an easier and more efficient way *Effectiveness* ● Cost-effectiveness *Other* ● Environmental goals *New objectives* ● Interoperability with other systems	Only for using Akkerweb, was already familiar with the solution	*Overall* ● Solution is easy to use ● Solution is easy to use for other employees ● Easy to get the solution to do what I want ● Easy to remember how to perform tasks *Improvements* ● Make it multiplatform (interoperability with other systems)	*Effectiveness* ● Solution does what it is supposed to do ● Influences end-yield in a positive way? *Efficiency* ● Accomplish tasks more quickly ● Saves time	*Technological* ● Need data for every piece of land before being able to use the solution ● Hard to remember how to perform tasks if you're not used to all systems involved (application used only for 1 month a year) *Informational* ● Smaller farmers could think the solution is not cost-effective for them (while it is)	3.9	N.a.
1.6: Data driven potato production	*Efficiency* ● Irrigation efficiency *Effectiveness* ● Counteracting pests/diseases (not used IoT for it yet)	Training on the field with the machine and a training on how to work with the application (how to view the data)	*Overall* ● Very easy to use ● Easy to understand ● Like the technology ● Solution provides guidance in performing tasks *Improvements* ● Alert system when you're not logged in (working on it already)	*Efficiency* ● Saves time ● Saves water (almost half) ● Saves costs ● Increases productivity *Effectiveness* ● Improves quality of work ● Solution is reliable ● Addresses job related needs ● Control of the work increases	*Technological* ● Need to understand smartphone ● No notifications when not logged in to system ● Solution needs more developing concerning the pest/disease predictions *Business & economic* ● Loss of harvest due to station (problem smaller farms) *Behavioural/social* ● Suspicious about technology at first, have to see results ● Older generations might be more sceptical, they might trust their own experience over the IoT solution	4.50	Yes, saves money and time
1.8 Solar-powered field sensors	*Effectiveness* ● Correct amount of water, nutrients and fertilizers	Basic instructions about what the values mean, for example the colours	*Overall* ● Navigations in the app are easy to understand *Improvements* ● Improve and activate	*Effectiveness* ● Addresses job related needs ● Useful in my job *Efficiency*	*Technological* ● Solution needs developing *Business/economic* ● Performance risk ● Trusting the solution 100% could be risky	N.a.	Wait until the results are clear, than buy and apply on larger piece of land

			• camera option • Need for larger database • Solution needs developing	• Increased efficiency (water) • More accurate decision making	*Behavioural/social* • Trust own knowledge above IoT solution (need to see that it works first) *Informational* • Might be hard to understand for farmers who don't have a background in physics		
2.7: Multi-sensor cow monitoring	*Efficiency* • Speed up production period • Improve efficiency: managing farm in an easier way *Effectiveness* • Detect animal health issues to prevent losing cows (death) *Other* • Spread the use of technologies in the breeding industry *New objectives* • Possibility of selling the animal with the bolus and the history provided by the system	Informed about the product and how to implement it: mounting the gateway and install the bolus	*Overall* • Very easy to use the solution • Exiting to work with the system • Solution is easy to use for others too • Support service • Support service and guarantees are provided in case of malfunction. *Improvements* • At the beginning there was an issue with how to add notes, this is adapted based on user needs already • Adapting alerts to breeding farm	*Efficiency* • Saves costs • Saves time (work) • Work-life balance increases when system is finalized *Effectiveness* • Solution provides accurate data • Hasn't tested the calving alert yet • Addresses job-related needs	*Technological* • System is 90% ready, cannot fully rely on it yet • System is optimized for dairy farming (not meat)/drinking alert too often • Needs an internet connection • No data memory when large distance between animals and gateway *Business & economic* • Questions about animal health and project results in the beginning • Opportunity to earn more money to sell animals with the bolus and it's information • Project results were not clear at the beginning *Behavioural/social* • Bad experience with previous technology (no IoF) • Open to trying new technologies (in this UC)	3.83	Already payed for solution (received discount)
3.3 Automated olive chain	*Effectiveness* • Automation of irrigation • Optimizing the irrigation • Disease detection	A session in which they described the application and how to use it	*Overall* • Solution is very easy to use • Solution is straightforward • Support service and guarantees are provided in case of malfunction. *Improvements*	*Efficiency* • Saves resources, time and money • Reduced time unproductive activities • Accomplish tasks more quickly *Effectiveness* • Addresses job-related needs	*Business & economic* • You need an adequate size farm • Shouldn't lose the connection with the field, you cannot leave all to the technology *Behavioural social/informational* • Older farmers might need a little more help with the technology	3.86	Yes, definitely. I have the installation and I just have to pay the yearly subscription, its affordable

			• Open main screen directly (not after pushing several buttons	• Solution is cost-effective • More control over the work			
3.4: Intelligent fruit logistics	• Process optimization using geo-positioning • Prevent food losses using temperature tracking	Basic training and learning by doing (with help)	*Overall* • Solution is easy to use	*Efficiency* • Saves money *Effectiveness* • Control of where crates are • Better quality control of fruit/veg	*Technological* • Battery of crate can run out (then you might lose it) • Reporting of data is time consuming • Need for better network (now using sigfox) • Need for smaller sensors *Business & economic* • High costs price of crates • Too many requests, can't serve all customers • Robbery might become issue in the future • Jammers could block sensors *Informational* • Possibilities are overestimated • Possibilities are underestimated	N.a.	Customers are willing to pay for the solution
4.1 City farming leavy vegetables	• Optimisation of indoor farming • Controlling quality	User gets training on how to use the system	*Overall* • Solution is easy to use • Solution is user friendly • Solution is interoperable with other systems • Clear visual dashboard	*Efficiency* • Saves time *Effectiveness* • Addresses job-related needs • More control over the work	*Technological* • Need for a simpler setup (less costly) for smaller farms *Business and economic* • Probably not cost effective for smaller farms *Informational* • Need for plant specialists to explain certain (growth) issues that may pop up • Important to show how it works and that the system works	3.87	N.a.
5.4: Decision-making optimisation in beef supply chain	• Notification/alert messages that cow is giving birth *New objectives*	Meeting to explain collars and how the application worked	*Overall* • Very easy to use • Solution is very intuitive	*Efficiency* • Save money • Reduced time unproductive activities • Saves time	*Technological* • Some collars broke *Business & economic* • Costs money to buy collars *Informational*	4.43	Maybe half of them, not all of them (depends on price)

	• Use farm data to take decisions (not a lot of data yet) • Weighting of the calves (does not work yet)		• Interaction with the solution is easy to understand • Easy to get the solution to do what I want • Support service and guarantees are provided in case of malfunction	*Effectiveness* • Addresses job-related needs • Useful in my job • More control over the work • Solution is mainly useful in specific months a year • Solution does what it is supposed to do • Improves (quality of) work •	• Sceptical about the solution (other similar technologies failed at other farms)		
5.5 Feed supply chain management	Main objective • Cost-effectiveness Related • Correct and on-time orders • Customer service • More efficient transport and production • Saving time	Web links, webinars and demonstrations within the organisation	*Overall* • Very easy to use • User friendly *Improvement suggestions* • Adding alerts • Providing more guidance/clarity about your last activity • Last/previous order box for all customers • Interoperability with other systems	*Effectiveness* • Addresses job-related needs • More accurate decision making • More control over the work • Improved confidence/job performance • Solution is reliable • Cost-effectiveness on large farms *Efficiency* • Accomplish tasks more quickly • Saves time • Reduced time in unproductive activities	*Technological* • Some monitors broke down and showed an error sign *Business/economic* • Questionable whether the technology would be cost-efficient in larger farms • Image risk • Performance risk *Social/behaviour* • Stakeholders/customers might be hold-back in accepting technology • Right involvement of people at the beginning • Lack of rust in the technology • Being sceptical about the technology	3.93	N.a.

Table 15: ease of use coding and numbers in Atlas.ti

	UC 1.8	UC 1.6	UC 2.7	UC 5.4	UC 1.1	UC 4.1	UC 3.4	UC 5.5	UC 3.3	Totals
Become confused	0	0	2	0	0	0	0	2	0	4
Easy to get the solution to do what I want	0	0	0	1	1	0	0	0	0	2
Easy to remember how to perform tasks	0	0	0	0	1	0	0	0	0	1
Frustrating to interact with solution	1	0	0	0	0	0	0	0	0	1
My interaction with solution is easy to understand	3	4	1	0	0	0	2	0	0	10
Requires lot of mental effort	0	0	0	0	1	0	0	0	0	1
Solution is easy to use	1	3	3	5	4	3	1	3	1	24
Solution is straightforward/intuitive	0	0	0	2	0	0	0	1	1	4
Solution is user friendly	0	0	0	0	0	1	0	2	0	3
Solution provides guidance in performing tasks	0	1	0	0	0	0	0	1	0	2
Support service and guarantees are provided in case of malfunction	0	0	2	1	0	0	1	0	1	5
Total	5	8	8	9	7	4	4	9	3	57

Table 16: usefulness coding and numbers in Atlas.ti

	UC 1.8	UC 1.6	UC 2.7	UC 5.4	UC 1.1	UC 4.1	UC 3.4	UC 5.5	UC 3.3	Totals
Accomplish more work	0	3	0	0	0	0	0	2	0	5
Accomplish tasks more quickly	0	1	1	0	2	0	0	6	1	11
Addresses job-related needs	6	5	2	6	2	1	2	4	2	30
Cost-effective	1	2	1	0	1	1	4	4	1	15
Customers are willing to pay for solution	0	0	0	0	0	0	1	0	0	1
Decreases mental effort	0	4	0	0	0	0	0	0	0	4
Easier to do job	0	1	0	0	2	0	0	0	0	3
Efficiency	1	2	0	1	3	0	0	0	1	8
Enhances effectiveness	0	1	1	2	0	0	0	0	0	4
Improved job performance	0	0	0	0	0	0	0	2	0	2
Improvement suggestions	6	1	0	0	2	0	0	4	1	14
Improves quality of work	0	1	0	2	0	0	0	0	0	3

Increases productivity	0	2	0	0	0	0	0	0	0	2
Interoperable with other systems	0	0	0	0	0	2	0	0	0	2
IoT technology is unmissable	0	0	0	0	1	0	0	0	0	1
Malfunction	1	0	3	3	0	0	0	3	0	10
More accurate decision making	1	3	0	0	0	0	0	1	0	5
More control over the work	0	5	1	7	0	1	3	3	1	21
Need data before being able to use solution	0	0	0	0	2	0	0	0	0	2
Not interoperable with other systems (yet)	0	0	0	0	6	0	0	2	0	8
Reduced time unproductive activities	0	2	0	1	0	0	0	2	3	8
Save money	0	2	1	1	0	0	2	0	2	8
Save resources	1	2	0	0	0	0	2	0	2	7
Saves time	1	2	1	1	1	3	0	11	2	22
Solution does what it is supposed to do	0	0	0	1	1	0	0	0	0	2
Solution gives wrong results	0	0	0	0	0	0	0	0	1	1

Solution is environmentally friendly	0	0	0	0	1	0	0	0	0	1
Solution is for free (only costs involved for data)	0	0	0	0	1	0	0	0	0	1
Solution is reliable	0	0	0	0	0	0	1	1	0	2
Solution needs developing	7	1	3	0	0	0	3	0	1	15
Solution only useful in certain periods a year	0	0	0	1	0	0	0	0	0	1
Solution provides accurate data	0	0	2	0	0	0	0	0	0	2
Takes time	1	0	0	4	2	1	0	2	0	10
Useful in my job	4	5	2	7	2	1	1	1	1	23
Total	31	45	18	37	29	9	19	48	19	255

APPENDIX 6: UAT QUESTIONNAIRE

IoF2020 WP4 User Acceptance Testing

Q25 Dear IoF2020 partner, This survey is a tool to support you increase user acceptance of IoT products and solutions. The survey offers a chance to **receive feedback from the IoT users** itself and allows to **identify acceptance problems** during the development cycle. The results of the test can be used to adjust the product according to the users' needs. We kindly ask you to fill-in this survey together with all the known test farms/ demo companies within your use case. The survey contains mainly multiple choice questions and takes approximately 10-15 minutes to complete. Honest opinion of the test farms/demo companies can help you and us to develop the product in a proper way. Thank you for your efforts and for sharing your opinion.

IoF 2020 Work Package 4 team

Q43 What is **the number** and **the name of the IoF use case** your responses refer to.

_____

Q45 What is the product/solution? Please describe it in a bit more details.

_____

Q46 Are you working on a test farm or in a company?

- ○ test farm (1)
- ○ company (2)

Q3 Information about test farm:

- ○ Name of the test farm: (1) _____
- ○ Name of the respondent: (2) _____
- ○ Address: (3) _____
- ○ Country: (4) _____
- ○ E-Mail: (5) _____
- ○ Mobile: (6) _____
- ○ Job name: (7) _____

Q47 Information about the company:

- ○ Name of the company: (5) _____
- ○ Name of the respondent: (6) _____
- ○ Adress: (7) _____
- ○ Country (8) _____
- ○ Email: (9) _____
- ○ Mobile: (10) _____
- ○ Job name: (11) _____

Q4 Age:

- ◯ < 29 (1)
- ◯ 30-39 (2)
- ◯ 40-49 (3)
- ◯ 50-59 (4)
- ◯ 60 + (5)

Q38 Gender:

- ◯ Male (1)
- ◯ Female (2)

Q6 Education level:

- ◯ Practical education (1)
- ◯ High School education (2)
- ◯ Bachelor's degree (3)
- ◯ Master's degree (4)
- ◯ Doctoral defree (5)
- ◯ Professional degree (JD, MD) (6)

Q7 Turnover/income in 2017 before taxes:

- ○ Less than 10.000 € (1)
- ○ 10.000 - 50.000 € (2)
- ○ 50.000 - 100.000 € (3)
- ○ 100.000 - 500.000 € (4)
- ○ 500.000 € and more (5)

Q48 Turnover/income in previous year before taxes:

- ○ Less than 100.000 € (1)
- ○ 100.000 - 500.000 € (2)
- ○ 500.000 - 5.000.000 € (3)
- ○ 5.000.000 - 10.000.000 € (4)
- ○ 10.000.000 - 40.000.000 € (5)
- ○ 40.000.000 € and more (6)

Q8 Farm focus:

- ☐ Arable (1)
- ☐ Dairy (2)
- ☐ Vegetables (3)
- ☐ Fruits (4)
- ☐ Meat production (5)

Q26 What kind of meat do you produce?

- ○ Pork (1)
- ○ Beef (2)
- ○ Poultry (3)

Q10 Farmed area (ha)

Q11 Number of employees/staff:

Q12 Do you already use the product/solution of our use case?

- ○ Yes, already applied in my farm or company (1)
- ○ We plan to apply within a year (2)
- ○ We are interested, but have no specific plans (3)
- ○ No, but maybe later (4)
- ○ Not at all (5)

Q14 Usefulness of the product/solution	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
The additional **benefit** of the product/solution of our use case for the farm is clear. (1)	○	○	○	○	○	○
I believe that the product/solution of our use case **reduce working time**. (2)	○	○	○	○	○	○
The product/solution of our use case clearly provides a more accurate **decision making**. (4)	○	○	○	○	○	○
I believe applying the product/solution of our use case fosters **public acceptance of farming**, as it helps to inform consumers about the production process of their food (5)	○	○	○	○	○	○
I believe applying the product/solution of our use case contributes to realizing **societal goals**, such as making farming more environmentally friendly. (6)	○	○	○	○	○	○
I think that the product/solution of our use case offers me more **benefits** than current practice. (7)	○	○	○	○	○	○

Q49 Usefulness of the product/solution	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
The additional **benefit** of the product/solution of our use case for the company is clear. (1)	○	○	○	○	○	○
I believe that the product/solution of our use case **reduce working time**. (2)	○	○	○	○	○	○
The product/solution of our use case clearly provides a more accurate **decision making**. (4)	○	○	○	○	○	○
I believe applying the product/solution of our use case fosters **public acceptance of farming**, as it helps to inform consumers about the production process of their food (5)	○	○	○	○	○	○
I believe applying the product/solution of our use case contributes to realizing **societal goals**, such as making farming more environmentally friendly. (6)	○	○	○	○	○	○

I think that the product/solution of our use case offers me more **benefits** than current practice. (7)	○	○	○	○	○	○

Q15 Please mention the three **most important features** that you find beneficial for your farm or company of this product/solution, if there are any:

_____

_____

_____

_____

_____

Q16 Please mention the three **least interesting features** of the product/solution, if there are any:

_____

_____

_____

_____

_____

Q17 Ease of use	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
The product/solution of our use case was easy to install. (1)	○	○	○	○	○	○
The design of the solution is easy to understand. (2)	○	○	○	○	○	○
The workflow of the solution is logically and delivers the result with few clicks. (7)	○	○	○	○	○	○
Accessing the solution on my mobile device works properly. (8)	○	○	○	○	○	○
The use of the product/solution of our use case needs special (ICT) expertise. (3)	○	○	○	○	○	○
The product/solution of our use case was easy to use and understand by all persons working with it. (4)	○	○	○	○	○	○
If not, which features where complex for your personnel to understand (open question). (5)	○	○	○	○	○	○
Support service and guarantees are provided in case of malfunction. (6)	○	○	○	○	○	○

Q18 Please mention the three most **important reasons for using** the product/solution:

_____

_____

_____

_____

_____

Q19 Please mention the three **most important reasons for NOT using** the product/solution:

_____

_____

_____

_____

_____

Q20 Technical quality and infrastructure	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
The farm has all necessary infrastructure (examples listed below) to install the product/solution of our use case right away. (1)	○	○	○	○	○	○
The product/solution of our use case is interoperable with all existing digital solutions and machines on the farm. (2)	○	○	○	○	○	○

Q50 Technical quality and infrastructure	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
The company has all necessary infrastructure (examples listed below) to install the product/solution of our use case right away. (1)	○	○	○	○	○	○
The product/solution of our use case is interoperable with all existing digital solutions and machines in the company. (2)	○	○	○	○	○	○

Q21 Which of the following **issues hinder the product/solution of our use case applications** in your farm or company (more than one answer is possible):

- ☐ Absence of Wi-Fi (1)
- ☐ Absence of internet connection at all (2)
- ☐ Connection is at very low speed (3)
- ☐ Absence of connection between data receiver and data transmitter (4)
- ☐ Batteries of the product/solution of our use case devices are weak (5)
- ☐ GSM network is not available (6)
- ☐ Difficult to find suitable mobile connectivity provider (7)
- ☐ No access to mobile coverage (8)
- ☐ The product/solution of our use case device (e.g. SIM card) uses only one of available telecommunication networks (9)
- ☐ The product/solution of our use case are not secure (10)
- ☐ The product/solution of our use case cannot stand the (seasonal) hot or cold temperature at our region (11)
- ☐ Telecommunication companies require long-term contracts which is not attractive (e.g. expensive) (12)
- ☐ Cancelation period with telecommunication providers is very long (13)
- ☐ Other, please specify (14)

_____

Q22 Application of digital solutions in general	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
I can repair and maintain digital solutions without external support. (3)	○	○	○	○	○	○
It is important for me to know the experience of fellow farmers about digital solutions. (5)	○	○	○	○	○	○
I think the offered solution is reliable. (6)	○	○	○	○	○	○
I am confident about using the digital solution. (7)	○	○	○	○	○	○
It is clear for me which data is being collected by the digital solution and who has access to it. (8)	○	○	○	○	○	○
By using the digital solution, I still have the feeling that I am in charge of my farm operation. I do not lose my autonomy. (9)	○	○	○	○	○	○

Q51 Application of digital solutions in general	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
I can repair and maintain digital solutions without external support. (3)	○	○	○	○	○	○
It is important for me to know the experience of companies about digital solutions. (5)	○	○	○	○	○	○
I think the offered solution is reliable. (6)	○	○	○	○	○	○
I am confident about using the digital solution. (7)	○	○	○	○	○	○
It is clear for me which data is being collected by the digital solution and who has access to it. (8)	○	○	○	○	○	○
By using the digital solution, I still have the feeling that I am in charge of my company operation. I do not lose my autonomy. (9)	○	○	○	○	○	○

Q42 How much do you pay (planned to pay) for the product/solution of our use case?

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_____

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Q23 Cost-efficiency and feasibility

	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
Using the product/solution of our use case can increase my farms productivity. (1)	○	○	○	○	○	○
Using the product/solution of our use case can increase my profits. (2)	○	○	○	○	○	○
Using the product/solution of our use case can reduce my costs. (3)	○	○	○	○	○	○
The price/quality ratio of the product/solution of our use case is fair (4)	○	○	○	○	○	○
I would recommend the product/solution of our use case to my neighbours and fellow farmers. (5)	○	○	○	○	○	○

Q52 Cost-efficiency and feasibility

	strongly agree (1)	agree (2)	neutral (3)	disagree (4)	strongly disagree (5)	not applicable (6)
Using the product/solution of our use case can increase my companies productivity. (1)	○	○	○	○	○	○
Using the product/solution of our use case can increase my profits. (2)	○	○	○	○	○	○
Using the product/solution of our use case can reduce my costs. (3)	○	○	○	○	○	○
The price/quality ratio of the product/solution of our use case is fair (4)	○	○	○	○	○	○
I would recommend the product/solution of our use case to other companies. (5)	○	○	○	○	○	○

Q27 Why does the product/solution of our use case increase your farm productivity?

_____

Q53 Why does the product/solution of our use case increase your company productivity?

_____

Q32 Why doesn't the product/solution of our use case increase your farm productivity?

_____

Q54 Why doesn't the product/solution of our use case increase your company productivity?

_____

Q28 Why does the product/solution of our use case increase your profit?

_____

Q33 Why doesn't the product/solution of our use case increase your profit?

_____

Q29 Why does the product/solution of our use case reduce your costs?

_____

Q34 Why doesn't the product/solution of our use case reduce your costs?

_____

Q30 Why is the price/quality ratio of the product/solution of our use case fair?

_____

Q35 Why isn't the price/quality ratio of the product/solution of our use case fair?

_____

Q31 Why would you recommend the product/solution of our use case to your neighbours and follow farmers?

_____

Q36 Why wouldn't you recommend the product/solution of our use case to your neighbours and follow farmers?

_____

Q37 We thank you for your time spent taking this survey. Your response has been recorded. You can expect the feedback and product development support from us in a short term.