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How does the Adoption of Digital Technologies Affect the Social Sustainability of Small-scale Agriculture in South-West Germany?

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ABSTRACT

The adoption of digital technologies is expected to impact the social sustainability of agriculture, in particular in the case of small and mid-sized family farms in Western Europe. Goal of this research was to assess these impacts, however widely accepted impact assessment schemes of social sustainability are missing. Against this background, a qualitative, two-stage Delphi survey was conducted in order to identify relevant impact categories of the adoption of digital technologies in family-operated small-scale farms of South-West Germany. The participating experts stated, for example, that the adoption of digital technologies on the farm could mean that new business models can be based on the use of digital technologies. However, they also stated that digital technology could overburden farmers, which could hinder digitization in this sector as a whole. Data protection and data security were also issues ranked highly important by the participants in the Delphi Process.

Keywords: *Digitization; social sustainability; Delphi methodology; Agribusiness; small-scale agriculture.*

1 Introduction

In the *2030 Agenda for Sustainable Development* by the United Nations and the 17 *Sustainable Development Goals*, agriculture is considered a key economic sector that addresses most of these goals (Sachs, 2015). In this respect, agricultural production has a central role for global sustainable development that needs to be assessed (Rockström et al., 2017). In addition, it should be noted that particularly in agriculture technological progress in recent decades has been instrumental in increasing food production (Bennett et al., 2021). In most industrialized countries, this was associated with major structural changes and primarily negative effects on the environment that also drives farm consolidation (Tsiafouli et al., 2015).

The increasing implementation of digital technologies in agriculture is currently seen as a further milestone in this development. Studies for Germany show that the associated potential for reducing negative environmental impacts and stabilizing the economic situation on farms can be considerable, especially in regions with small-scale agriculture (Busse et al., 2014).

There is a variety of reasons for the limited assessment of the social dimension of sustainability in agriculture, including the lack of consensus with respect to its measurability, difficulties in the definition of system boundaries, and the complexity of social aspects (Toussaint et al., 2021). Furthermore, available concepts of sustainability measurement cannot, or only to a limited extent, applied to agriculture with production processes largely determined by nature. Thus, the extent to which digital technologies influence the work and coexistence of people on farms, particularly in regions with family-operated small-scale agriculture such as South-West Germany, has not yet been investigated. This is the background for this study, which addresses the question of how the adoption of digital technologies would influence the social sustainability of small-scale agriculture in South-West Germany.

2 State of the research: Measuring the social dimension of sustainability in small-scale agriculture in South-West Germany with the adoption of digital technologies

In sustainability assessment, the social dimension is frequently neglected, although the triangle of sustainability gives it the same importance as economic and ecological concerns (Vallance et al., 2011). Reasons are due to difficulties in measurability and the complexity this dimension entails (Popovic et al., 2018). The economic dimension can largely be quantified and mapped using the concepts of profitability, total cost of ownership (TCO), or total life cycle costing (Mohamad et al., 2014). For quantifying the ecological dimension, life cycle assessment-based environmental indicators have been widely accepted (Castoldi and Bechini 2010). A consensus on indicators for social sustainability is, however, by and large lacking (Janker et al., 2019). Proposed indicators such as job satisfaction, stress levels or work-life balance are perceived differently by each individual and cannot be easily integrated into a sensible aggregated indicator (Janker and Mann, 2020).

Previous studies have found that jobs in general are anticipated to become more diverse in the course of digitization. This development will have a profound social impact as it will change the way people live together (Makridakis, 2017). Jobs could thus become more demanding, but also more enriching for those who can meet the demands of the labour market. One of the most important causes for these effects in most industries is the high proportion of standardized work processes, which are excellently suited for digitization. Agriculture is also affected by digitization, though the work situation cannot be easily compared with other industries (Panetto et al., 2020; Ehlers et al., 2021). Furthermore, due to the handling of "living factors of production" (i.e. crop plants, animals and humans), work processes are far less standardizable than in e.g. the manufacturing sector.

Whilst a few international guidelines recommending concepts for the assessment of social sustainability have been in place for quite some time, it is obvious that most of them do not address the specific conditions in agricultural production and farm structure in sufficient detail. A few examples include:

- UNEP-SETAC (United Nations Environment Programme – Society of Environmental Toxicology and Chemistry). Guidelines for social life cycle assessment of products (SLCA) (UNEP SETAC, 2009) propose indicator systems for the assessment of social sustainability in different industries (Kühnen and Hahn, 2017). However, the indicators do not address the specifications of agriculture, in particular small-scale farming without a profound adjustment (Umair et al., 2015; Zamani et al., 2018; Karlewski et al., 2019; Frank et al., 2012).
- The SAFA Guidelines (Sustainability Assessment of Food and Agricultural Systems, (SAFA, 2014)) of FAO (Food and Agricultural Organization) (Scialabba 2014, p. 33), which propose indicator systems for social sustainability in agricultural systems, do not focus on the special structural circumstances under which European small-scale farms operate. It should be noted, however, that the logic of this indicator system

is focused more on small-scale farming in developing countries and therefore does not accurately reflect how potential impacts can be assessed (Bonisoli et al., 2019; Gayatri et al., 2016; Soldi et al., 2019). Moreover, as far as the system boundaries are concerned, these guidelines do not entirely reflect the situation on an individual farm in light of the potential adoption of digitally-enabled strategies. In addition, the global applicability of these guidelines has the disadvantage that country-specific differences in social standards are not adequately reflected. For example, the legal framework covering labour rights in developed countries differs profoundly from that in many developing countries where issues like child labour and forced labour are less of a concern (Beschorner and Müller 2007).

- The system RISE (Response-Inducing Sustainability Evaluation), which is used by consultants to assess farm sustainability. It addresses twelve indicators, whereby only the two indicators "working conditions" and "social security" deal with social issues. In this tool, social sustainability is underrepresented, and, as in SAFA and UNEP SETAC, the digital aspect is not taken into account (Thalmann and Grenz, 2013, p. 109; Häni et al., 2007, p. 127).

The daily work in agriculture makes the assessment of social aspects even more difficult because in contrast to industrial production in closed systems, farmers work outdoors with nature (Janker et al., 2019). Many activities can only be carried out when the external conditions are adequate. As a result, farmers do not have a classic workday with a fixed number of working hours, a regular weekend and a fixed number of vacation days. During work peaks (e.g. during harvest), which occur at regular intervals, farmers are exposed to an overload that they and their families have to cope with. In addition to this workload, farmers do not know how much the harvest will be and what price they will receive for their crop (Janker 2020). This uncertainty also has a social impact, as farmers do not know the level of remunteration, whether they will earn money from their work and whether the farm can still be managed economically in the future.

To better understand how the adoption of digital technologies might affect the social dimension of sustainability in small-scale agriculture, South-West Germany was used as a focus area. This region is characterised by small-scale agriculture, which applies to both farms and the agricultural landscape. Many farms are run on a part-time basis and the average field size is significantly smaller than in other regions in Germany (Ivemeyer et al., 2018). In family-operated farms, the separation between work and leisure time is almost impossible. In addition, there are seasonal recurring labour peaks that the family has to handle every year. If animals are kept on the farm, the workload increases further and the separation between leisure and work becomes even more difficult (Kirkhorn et al., 2010). Such examples indicated that the use of digital technologies have a profound impact on social sustainability.

As the social dimension of sustainability is expected to be of great importance regarding the future viability of farms, a qualitative survey was conducted in this study to assess the impact of the adoption of digital technologies on social sustainability in family-operated small-scale farms of South-West Germany. In this research, the term "digitization" was used very broadly and no definition of digital technologies was provided to the participants of the survey. Each participant was supposed to answer the questions according to his or her own personal judgement.

3 Material and Methods

3.1 Methodological approach

The scientific literature shows that there are different approaches to qualitative questioning in which predictions and future developments are made (Garbarino and Holland, 2009, p. 7). In order to predict which social impacts digitization will have on small-scale family farms in South-West Germany, a Delphi survey was conducted with experts. This qualitative method is used when the research field is new and there is little or no literature available (Rikkonen and Tapio, 2009). The Delphi method was developed in the 1950s with the aim of predicting the future (Akins et al., 2005). Nowadays, this method is established in a wide variety of fields and is now used in the most diverse areas of application (Trevelyan and Robinson, 2015). In this study, the aim was to develop a consensus on how digitization in agriculture affects the social dimension of sustainability. In Delphi surveys, several rounds of questioning are conducted until the experts reach a consensus on the issue being questioned (Aldrighetti et al., 2021). A standardized questionnaire with predefined answers is distributed to the participating experts. After a successful response to the first round of questioning, the questionnaire is evaluated and the experts receive it once again, supplemented with the answers of the first round, so that they can reconsider their decisions. This procedure is repeated until a consensus is reached among the experts. According to Keeney et al. (2001), however, two rounds of questions are typically sufficient to reach a consensus, since the marginal utility decreases with each additional round and fewer and fewer experts participate with each additional questioning. The following illustration shows the process of a Delphi survey (Köck-Hódi and Mayer, 2013).

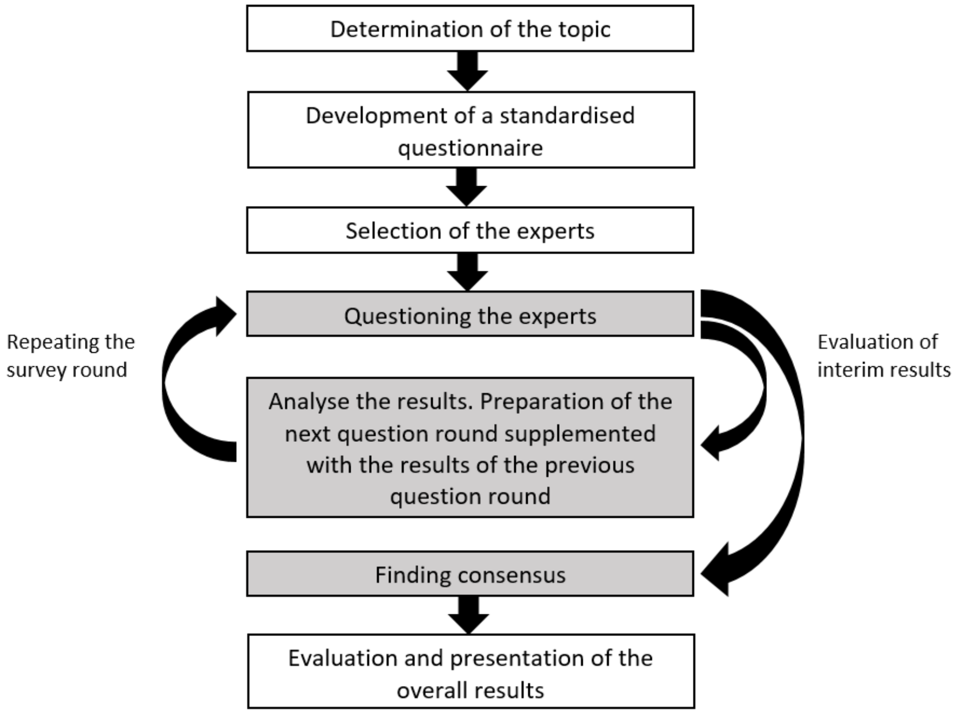

Figure 1. Procedure of Delphi (Köck-Hódi and Mayer, 2013).

3.2 Selection of experts

The right choice of experts has an important influence on the outcome of a Delphi survey (Allen et al., 2018). In addition to the technical expertise, the number of experts is an important influencing factor as well. According to Kühnen and Hahn (2019), an optimal number of experts is reached with 10-30 participants. Although involving more experts might result in more insights, studies have shown that the results are not necessarily more accurate with a larger number of experts. Moreover, consensus building becomes increasingly difficult with more participants (Boulkedid et al., 2011). The selected experts in this Delphi survey were active in the following professional groups:

Practicing farmers: Farmers work every day in arable cropping, using digital tools to optimize their production such as site-specific fertilization and site-specific sowing.

Rural science: Rural science deals with all kinds of social issues and should therefore be part of the study. The experts in this category were chosen because of their publications in social sustainability and their jobs in companies and universities.

Agricultural consulting: This group of experts works closely with farmers and advises them on all issues related to agriculture and farm management. As a consequence they have experience how digital technology affects the family situation on the farms, which is inevitably linked to social sustainability.

Digitization: In this group, experts were interviewed who work closely with farmers and for companies that offer and sell digital technology. This group also includes experts who conduct research in the field of digital technology and therefore have a great knowledge in this area.

Applied agricultural research: These experts work on projects in companies, associations, and universities that deal with both digitization in agriculture and the social development of this technology.

Science/Teaching: All the experts interviewed in this category work at universities and teach subjects related to digital technology, sustainable regional development, and social sustainability.

Figure 2 shows how the 30 experts were distributed among the individual areas of involvement. Furthermore, it should be mentioned that all experts were from Germany.

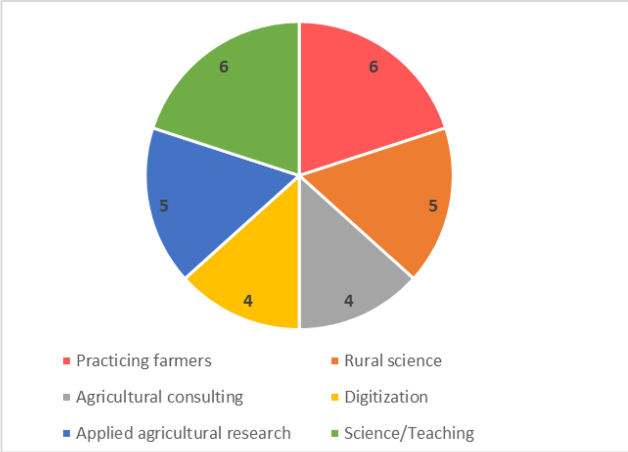

Figure 2. Distribution of experts*.

In the selection process, attention was paid to an even distribution of the experts in the different professional areas (Fig. 2). In this way, a more balanced view on social sustainability should be reflected, resulting in a more comprehensive assessment. The entire Delphi survey was anonymous and not all of the contacted experts took part in the survey. Because of the anonymity of the survey, it was not possible to determine whether experts in a particular field participated more often, less often or not at all.

The competences of academic experts were selected through research, e.g. based on publications in the field of social sustainability. For the other expert categories, the network of Nuertingen-Geislingen University was used as a base that ensured appropriate expert considerations.

3.3 Questionnaire

The SLCA Guidelines were used as a template to create the questionnaire (UNEP SETAC, 2009). The guidelines are recognized worldwide and have been considered suitable for dealing with the research question.

After an initial pre-test, the participating experts were sent a standardized questionnaire by email containing 17 questions divided into six categories: working hours (three questions - quantitative), training/workplaces (five questions - quantitative), data protection (two questions - quantitative), marketing (four questions - quantitative), barriers to digitization (two questions - quantitative) and other (one question - qualitative). All quantitative questions had predefined answer options on a scale of one to six, so that a quasi-metric level of measurement could be applied (Wu and Leung, 2017). In the last qualitative question, the experts were asked what digitization means to them in the context of social sustainability. A total of 20 experts participated in the first round of the survey. In the second round, the number of participants decreased to 14, but the consensus on the individual questions improved.

4 Results

Fig. 3 shows the answers to the 16 questions that the experts had given in the two rounds of the survey. In this graph, both the arithmetic mean and the median are shown in order to be able to determine whether the dispersion of the answers given by the experts differed substantially between the different questions. Question 17 was asked in an open-ended format and is therefore not part of these charts. Each individual question and the corresponding distribution of answers can be viewed in the appendix (Appendix 2). A summary overview on analysis is provided in appendix 3.

* This figure shows that a total of 30 experts from different disciplines were interviewed. However, due to the anonymity of the survey, it was not possible to say how many experts from the different disciplines participated. In question round one, 20 experts took part and in question round two there were 14. In both survey rounds, only these 30 experts were interviewed. The allocation to the individual disciplines was made by the authors.

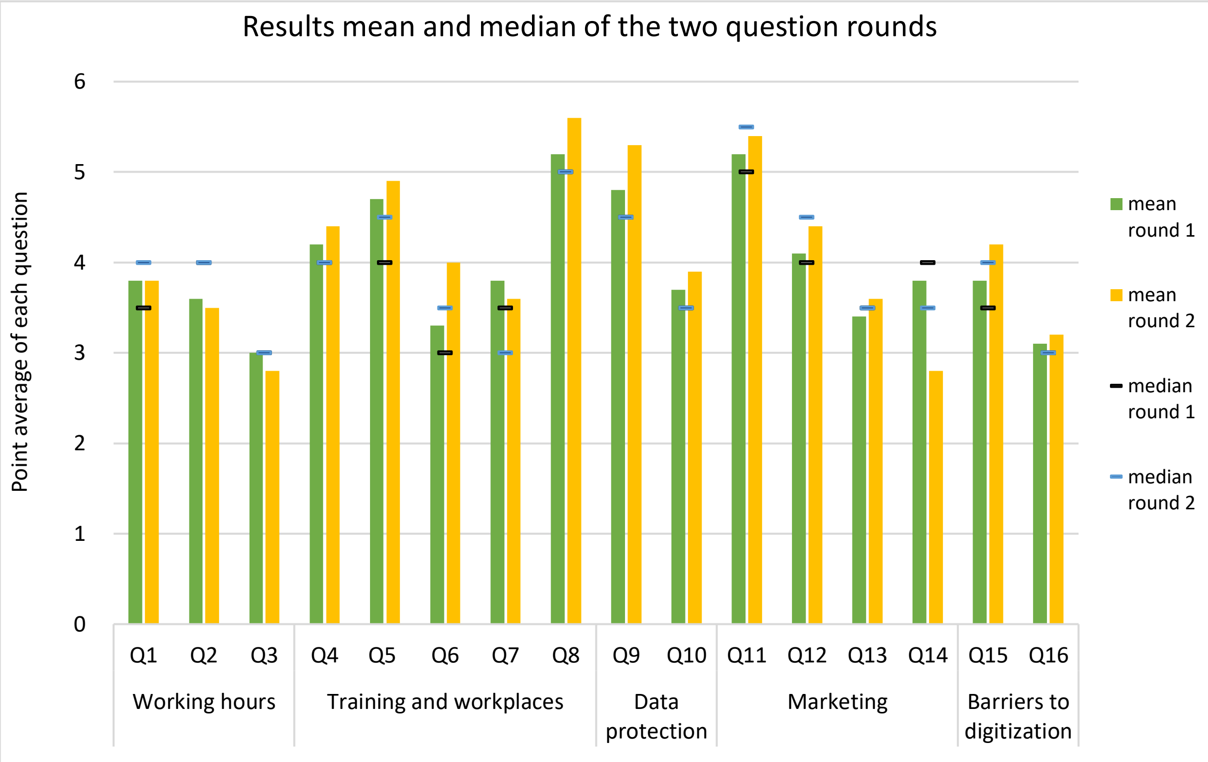

Figure 3. Answers of the experts in the individual questions.

Overall, for most of the questions asked, no strong devitation of the results from round 1 and round 2 of the survey were found. In the topic area “Working hours”, no major changes were found between the first and second round. What is striking here is that both the arithmetic mean and the median of the answers scored rather in the middle range, i.e. between values 3 and 4.

In the second topic area “Traning and workplaces”, outliers were identified for questions Q4, Q5 and Q8. The arithmetic mean increased for both questions in the second round, which indicates that the experts have become more confident with respect to their judgement. For question Q6, there is even a clear increase in the arithmetic mean after question round two.

In the topic area “Data protection”, a relevant change between question round 1 and 2 was found for question Q9. After the second round of questions, more experts expressed their view that there is a risk that farmers' data could be misused in the course of digitization.

In the topic area “Marketing”, the result for question Q11 should be highlighted. For this question, a clear result was already obtained in the first round of the survey and the values increased again after the second round. For question Q14, the change was even substantial. In the second round of questions, more experts expressed their views that digitization will not make food cheaper and that efficiency gains will not be passed on to the end consumer.

In the last topic area “Barriers to digitization”, there was a slight change between round 1 and 2 of the survey for question Q15. In the second round of questions, the experts were more certain that smaller farmers tend to face a competitive disadvantage in response to digitization. This finding was reinforced in question round 2 in contrast to the first question round. Overall, the results in this topic area score in the medium range between values 3 and 4.

5 Discussion

Digitization has been heralded as a revolutionary driver of change in the way how operations are carried out and how various stakeholders within the respective value chains interact (Xu et al., 2018). Digitization efforts have already been shown to profoundly impact the way workplaces for employees will be designed in all industries: typical jobs in the manufacturing sector, in office and commercial services are declining whereas occupations related to information technology, science or teaching are on the rise due to new requirements on skills and especially those with social and communication competences (Piazolo and Dogan, 2020). With regard to working conditions, studies show that with digitization, employees are partly required to be more flexible in terms of time. The flexibility of everyday working life has been shown to increase (Vuori et al., 2019). This includes deadline pressure, overtime and changing working hours which means that work and leisure time will become more and more intermingled as employees' accessibility through digital tools will increase (Harteis, 2019, p. 86). This development is new and raises questions that are both legal and social in nature. However, the strongest effects are seen in changing work content.

The Delphi methodology in this paper was chosen because it allows one, with a manageable number of experts, to obtain a picture of key impacts of digitization on the agricultural industry (Boulkedid et al., 2011). The advantages of this, apart from the small number of experts, are that a consensus should emerge at the end of the survey. Furthermore, individual opinions are not weighted too heavily, which has a positive effect on the credibility of the final results (Keeley et al., 2016). The disadvantage of this methodology is that the results are not representative (Gracht and Darkow, 2010). Furthermore, the selection of experts is in the hands of the person conducting the survey. It may happen, and is even quite likely, that not all experts in a field are included in the study and that selected experts are part of the study but do not actively participate. Furthermore, experts may have participated in only one round of the survey. This could distort the variety of responses because those experts do not have a comparison of their answers, in contrast to the experts who took part in both survey rounds. This weakness was known in advance and is inherent in the Delphi method. Nevertheless, the method was convincing because the advantages outweighed the disadvantages of gaining knowledge in a new area of research.

In this study, it became apparent that the experts are uncertain about most of the potential impacts of the adoption of digital techhnologies in family-operated small-scale farms in South-West Germany as selected for this Delphi process. This is strongly indicated by the lack of a clear tendency towards higher of lower scores for most of the questions. Mostly, scores of 3 to 4 for the arithmetic mean and the median were scored, as illustrated in Fig. 1. This is consistent with the findings of Desa and Jia (2020), who concluded that certain predictions for the agricultural sector, in terms of social impacts, cannot be made accurately. This sector is currently in transition and more research is needed to make accurate predictions. This clearly indicates that surveyed experts are hesitant to provide a clear prediction how the adoption of digital technologies in family-operated small-scale agriculture of the South-West Germany will affect the social dimension of sustainability at least in light of the topic areas addressed in this Delphi study. Only for questions Q4, Q5, Q8, Q9 and Q11 are tendencies discernible in the experts' answers. What is interesting about all these questions is that the arithmetic mean increased in the second round of questioning. The result, which was already quite clear after the first round, was then confirmed once again. Only for these five questions the experts provide a more certain view where the trend is heading. Although the answers to questions Q6 and Q15 also scored medium values, clearer results emerged in the second round. In both questions, a trend developed in the second round that was not initially discernible. This indicates that the experts are very certain about the future development of these two issues in this complex topic. For question Q6, the experts agree with Badiuzzaman and Rafiquzzaman (2020), who state that digitization will lead to a loss of jobs in all sectors of the economy. Question Q15 asked whether smaller farms are being left behind in the course of digitization because they are unwilling or unable to invest. The experts share the opinion of Deichmann et al. (2016), who show in their publication that new technologies are associated with high costs when they are launched on the market, but that these fall substantially after a certain period of time, as is the case with the Internet or telecommunications, for example.

There are various reasons why no clear results were obtained here. One of them is certainly the difficulty of approaching the concept of social sustainability (Fielke et al., 2021) such that the selected topic areas might not have been fully in line with the concepts of the questions. There are evaluation tools, as was shown in chapter 2. However, there is a lack of clear and globally applicable indicators. Another reason for the disagreement is that digitization in agriculture, especially in small structures such as those prevalent in South-West Germany, is a slow process that is only gradually picking up speed (Kos and Kloppenburg, 2019). It should also be mentioned here that network expansion and the infrastructure for this in rural areas are often insufficient to fully utilize digital technologies (Haefner and Sternberg, 2020; Bacco et al., 2019).

Unlike other professions in industrial manufacturing, agriculture is less standardizable and plannable (Iglesias et al., 2012), which means that many digital technologies can only be used to a limit extent, depending on the time of year and the time of day. In addition, farmers are highly dependent on the weather and need to be flexible to changing conditions. As a result, digitization is inextricably linked to the social dimension of sustainability (Serbulova et al., 2019; Ingram and Maye, 2020). This area is wide-ranging and affects all the areas covered in this questionnaire. Whether it is about working time, jobs, data security, marketing or barriers to digitization, each area inevitably has a social component that affects agriculture. As digitization in agriculture is still an emerging topic, there have been no scientific studies to date. This publication is therefore a first step into a new field of research. It should be noted that digitization is an ongoing process (Ozdogan et al., 2017). The results of this survey could change because farmers are antcipated to increasingly adopt digital technology.

6 Conclusion

The agricultural industry is affected by digitization in a very specific way. The diverse activities and complexity of agroecosystems (Panetto et al., 2020) make the use of digital technologies difficult. Unlike in the manufacturing industry, which takes place in more closed and controlled systems, individual work steps in agriculture can only be taken over by digital technology to a limited extent. Another characteristic of agriculture is that monotonous and labour-intensive activities that are often carried out manually by low-skilled and low income workers. Long working days are unavoidable for example during the labour-intensive harvest season. As a result, fewer and fewer people are choosing to work in agriculture. At the same time, social pressure on the work of farmers is constantly increasing, as they are often associated with environmental problems and "farming". With ever lower producer prices for food and ever greater demands from customers and politics, there are many farms that can no longer operate economically and are forced to give up.

Against this background, there are enormous opportunities in the increasing and emerging digitization of agriculture. Digital technology can reduce the workload, especially in labour-intensive and monotonous activities. Moreover, it can help to conserve resources, which has a positive impact on the environment. In addition, digital technology can help to bring more transparency into the individual value chains, which can open up new business models for farmers. Direct marketing is a model in which the enormous price pressure from food retailers can be circumvented. The broader distribution of business models also reduces the risk of a farm to a considerable extent. These new possibilities brought about by digitization inevitably have an impact on the social component. Satisfied customers and appreciation for one's own work increase self-esteem and change the lives of people working in agriculture.

This Delphi survey was used to find out how digitization in agriculture affects the social dimension of sustainability. As this is a qualitative method in which the opinions of a small number of experts were asked, this study is not representative. However, it gives a first perspective on this still new field of research. In order to gather more information in this field, a representative survey with farmers is planned. With this survey, the results in this work can be further consolidated and concretized.

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Appendix 1: Consolidated overview on questions

Table A1.1.
Questions from the questionnaire with short form.

Short form	*Question*
Q 1	*With the help of digital technology, the working time of employees on farms is reduced?*
Q 2	*The opportunities brought by digitization have a positive impact on the work-life balance of farmers.*
Q 3	*Digital technology takes decisions away, reducing the stress potential of the plant manager.*
Q 4	*How do you assess the risk of digital technology overburdening farmers, resulting in a slow uptake of this medium?*
Q 5	*Will the digitization of agriculture ensure that new jobs are created in this industry? (E.g., digitization officer)*
Q 6	*Will the increasing use of digital technology contribute to a decreasing demand for human labour in agriculture?*
Q 7	*Will digitization in agriculture contribute to the elimination of workers in the lower wage range?*
Q 8	*To what extent do you see the risk that digitization in agriculture will create dependencies on manufacturers/vendors?*
Q 9	*How do you see the risk that by using digital technologies farmers' data could be misused?*
Q 10	*How do you assess the risk of hacker attacks being a serious obstacle to the digitization of agriculture?*
Q 11	*To what extent do you agree with the following statement: Digitization helps the farmer with cost calculation?*
Q 12	*Digitization helps farmers open up new business models because end consumers gain more insight into how food is produced?*
Q 13	*The use of digital technology gives consumers a better understanding of how food is produced and its actual value, because the value chain becomes more transparent. To what extent can this help reduce food waste?*
Q 14	*Can it be assumed that digitization in agriculture will make food cheaper in the future because the more efficient use of resources will be passed on to the end consumer?*
Q 15	*How would you rate the following statement: Smaller farms are left behind in digitization because the investment sums are too large for a single farm?*
Q 16	*Increasing digitization in agriculture could contribute to the abolition of the profession of farmer and these activities then being taken over by large corporations. How do you assess this fear?*
Q 17	
Q Round 1	*What other impacts on social sustainability, not already addressed in the questionnaire, do you expect in the course of digitization in agriculture?*
Q Round 2	*Please define what "digitization" means to you personally in the context of social sustainability?*

Appendix 2: Detailed Respones to Questions

A2.1 Working hours: (three questions)

Question 1 (Figure 4): *With the help of digital technology, the working time of employees on farms is reduced?* With an arithmetic mean of 3.8, the majority was of the opinion that working time will be reduced.

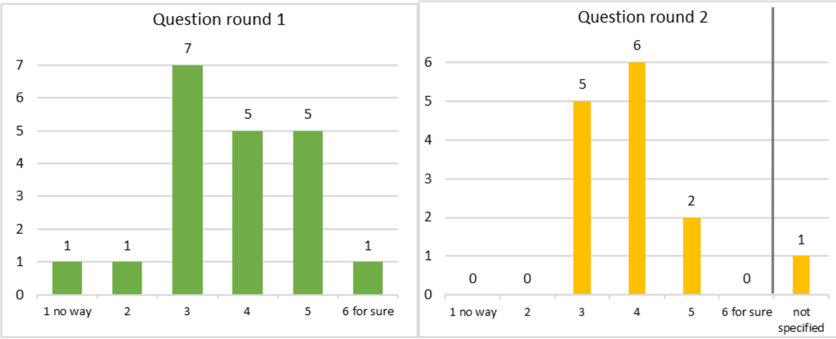

Figure A2.1. Question No 1.

Question 2 (Figure 5): *The opportunities brought by digitization have a positive impact on the work-life balance of farmers.* With an average of 3.5, i.e. exactly in the middle of the result range, the experts were not sure whether digitization improves or worsens the work-life balance.

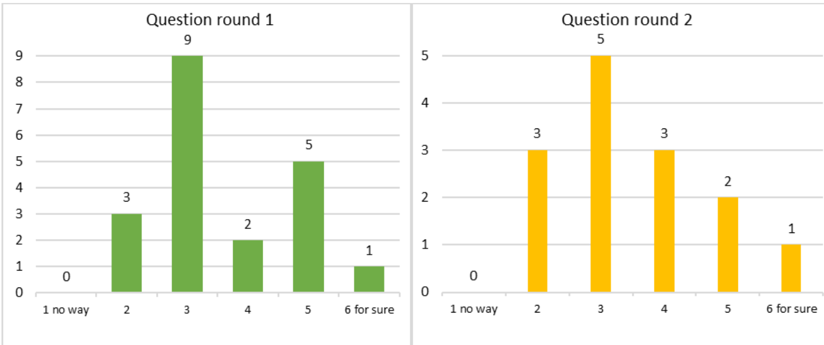

Figure A2.2. Question No 2.

Question 3 (Figure 6): *Digital technology takes decisions away, reducing the stress potential of the plant manager*. In this question the participants were certain that the stress potential of the farm manager in decisions does not tend to decrease due to digitization. With an average of 2.8, the experts were of the opinion that digitization may not siginificatly reduce the stress level farm managers have to cope with.

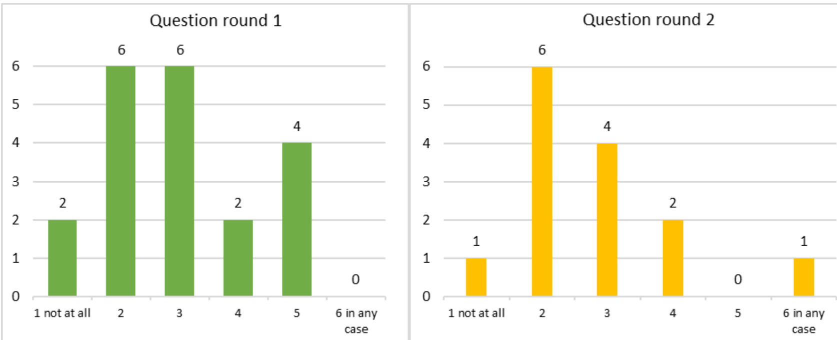

Figure A2.3. Question No. 3.

A2.2 Training/workplaces: (five questions)

In the second set of questions, the impact of digitization on training/workplaces was addressed in five questions.

Question 4 (Figure 7): *How do you assess the risk of digital technology overburdening farmers, resulting in a slow uptake of this medium?* Overall, the participants saw an increased risk in this area (average 4.4).

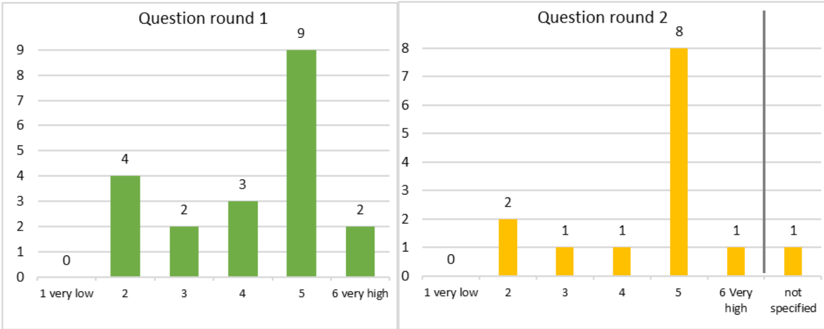

Figure A2.4. Question No. 4.

Question 5 (Figure 8): *Will the digitization of agriculture ensure that new jobs are created in this industry? (E.g., digitization officer).* Here, too, the experts were certain that digitization will create new jobs in this sector. The average of 4.9 supports this statement.

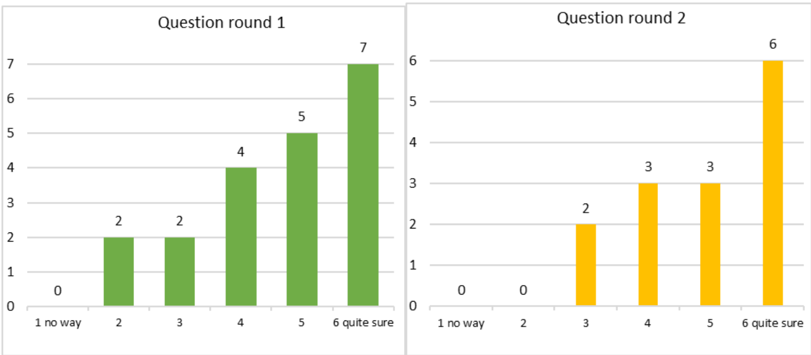

Figure A2.5. Question No. 5.

Question 6 (Figure 9): *Will the increasing use of digital technology contribute to a decreasing demand for human labour in agriculture?* While the previous question (question 5) dealt with the creation of new jobs, the focus of this question is on existing jobs. The majority of experts were certain that jobs will tend to disappear in the course of digitization (average of 4.0).

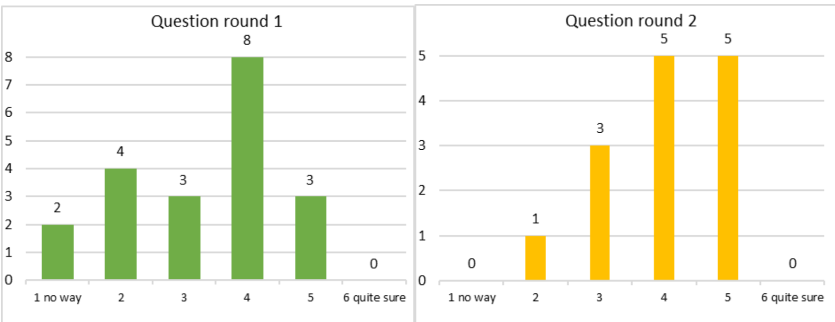

Figure A2.6. Question No. 6.

Question 7 (Figure 10): *Will digitization in agriculture contribute to the elimination of workers in the lower wage range?* The experts disagreed on this statement. Although the average of 3.6 was fairly central, the composition was such that some experts gave a value of five and some gave a value of three. Five experts said that jobs in the lower segment will tend to disappear as a result of digitization, while five others said exactly the opposite.

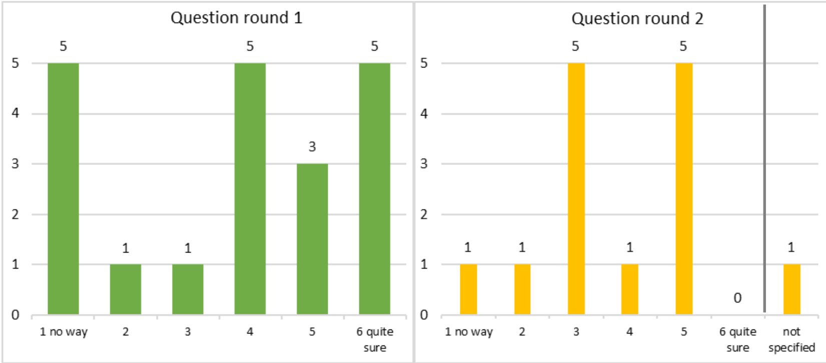

Figure A2.7. Question No. 7.

Question 8 (Figure 11): *To what extent do you see the risk that digitization in agriculture will create dependencies on manufacturers/vendors?* Results show a high level of agreement among experts. Almost all respondents saw a very high risk in this dependency. With an average of 5.6, most experts gave a value of six. Dependencies on manufacturers of digital technology are thus seen as a very high risk for farms.

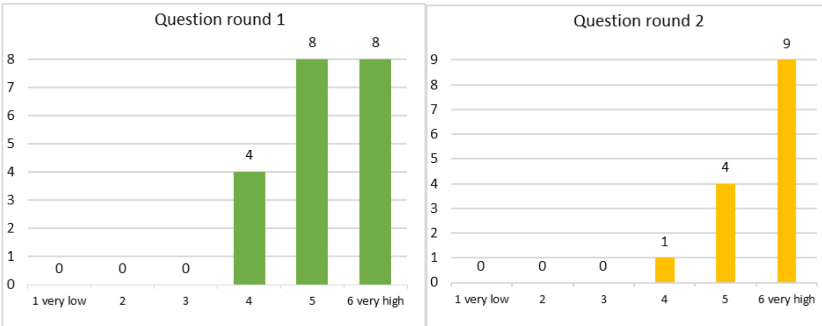

Figure A2.8. Question No. 8.

A2.3 Data protection: (two questions)

The topic area of data protection involved two questions:

Question 9 (Figure 12): *How do you see the risk that by using digital technologies farmers' data could be misused?* With an average of 5.3, the majority of experts agreed that there was a very high risk associated with the misuse of data.

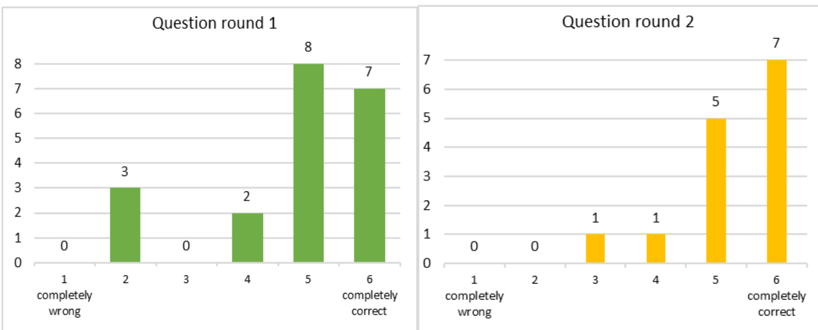

Figure A2.9. Question No. 9.

Question 10 (Figure 13): *How do you assess the risk of hacker attacks being a serious obstacle to the digitization of agriculture?* In both Delphi rounds answers were distributed very differently. Although answers have become more condensed in the second Delphi round, distributions of results do not show a clear tendency. Overall, the majority of participants saw an increased risk in hacker attacks, which was reflected in an average of 3.9.

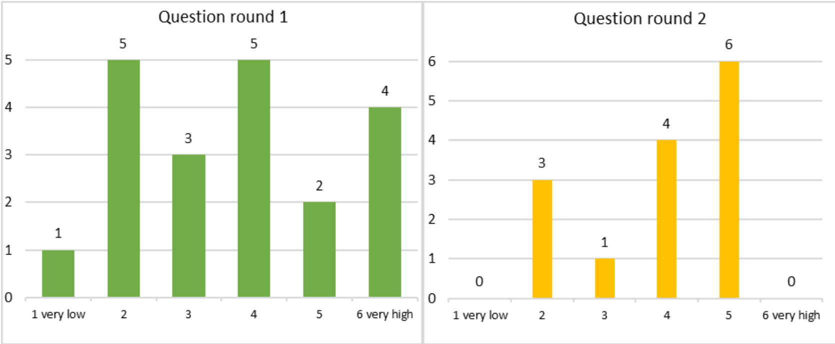

Figure A2.10**.** Question No. 10.

A2.4 Marketing: (four questions)

In the marketing section, a total of four questions were asked:

Question 11 (Figure 14): *To what extent do you agree with the following statement: Digitization helps the farmer with cost calculation?* With an average of 5.4, a clear majority of respondents indicated that digitization helps farmers to better control income and expenditure, which has a positive overall effect on cost calculation.

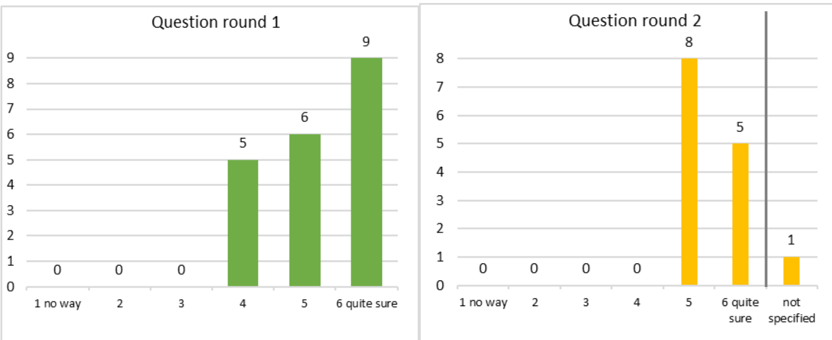

Figure A2.11**.** Question No. 11.

Question 12 (Figure 15): *Digitization helps farmers open up new business models because end consumers gain more insight into how food is produced?* The results showed a clear picture after Delphi round two. With an average of 4.4, the majority of respondents were convinced that farmers can open up new business models through digitization. Through the further development of digitization, consumers will gain more insights into agricultural production in the future. With increasing interest in agricultural activities, new business models can be realised as work steps associated with food production are made visible to the consumer.

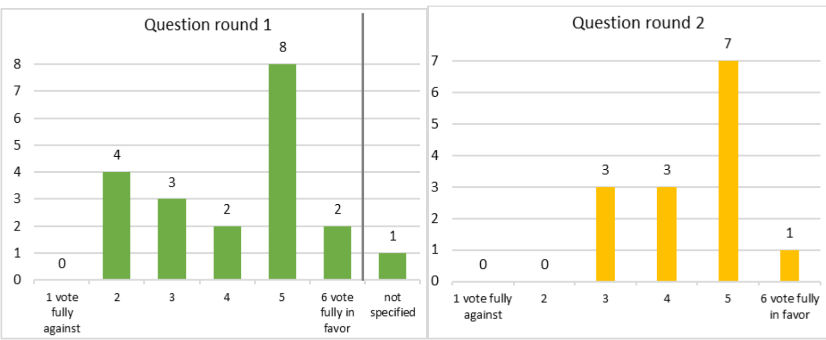

Figure A2.12**.** Question No. 12.

Question 13 (Figure 16): *The use of digital technology gives consumers a better understanding of how food is produced and its actual value, because the value chain becomes more transparent. To what extent can this help reduce food waste?* No uniform result was achieved with this question (average 3.6). Even after the second round of questions, the answers were widely distributed, which means that no conclusive statements can be made here. About half of the experts were of the opinion that transparency can reduce food waste while the others did not see this connection.

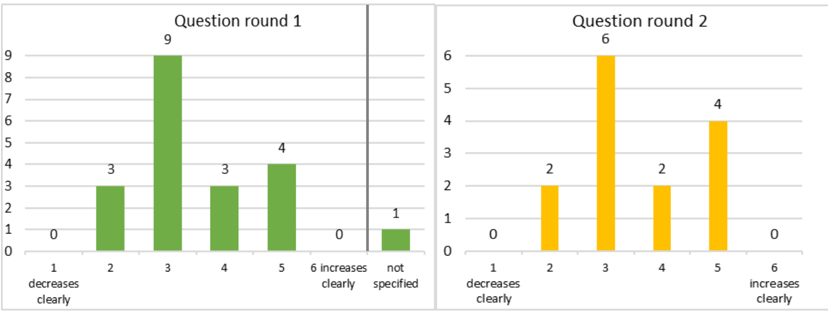

Figure A2.13**.** Question No. 13.

Question 14 (Figure 17): *Can it be assumed that digitization in agriculture will make food cheaper in the future because the more efficient use of resources will be passed on to the end consumer?* The experts uniformly voted against this statement. With an average of 2.8, the respondents were certain that digitization will not contribute to cheaper food.

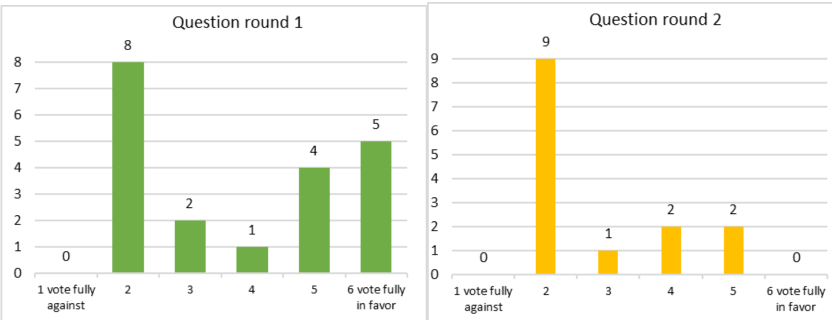

Figure A2.14**.** Question No. 14.

A2.5 Barriers to digitization: (two questions)

Whether the path to digitized agriculture will encounter obstacles is addressed in the next two questions:

Question 15 (Figure 18): *How would you rate the following statement: Smaller farms are left behind in digitization because the investment sums are too large for a single farm?* With an average of 4.2, the majority saw this as a risk. Especially in South-West Germany, a region with an above-average number of small-structured farms and a high proportion of sideline businesses, this can lead to barriers towards digitization.

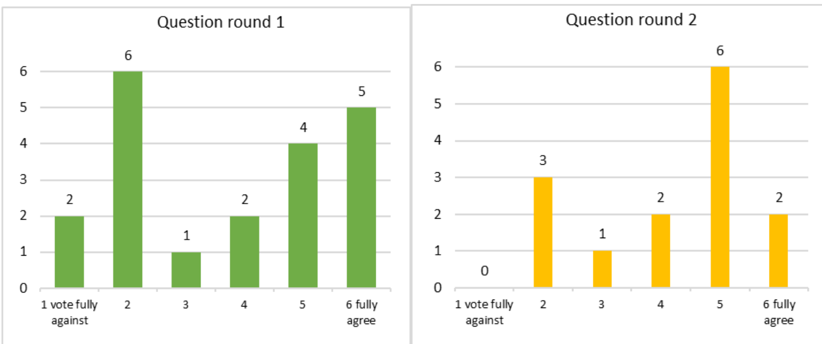

Figure A2.15**.** Question No. 15.

To conclude this category, the experts had to give an assessment of whether they feared that the profession of farmer would be abolished by increasing digitization because these activities would be taken over by large corporations in the future.

Question 16 (Figure 19): *Increasing digitization in agriculture could contribute to the abolition of the profession of farmer and these activities then being taken over by large corporations. How do you assess this fear?* Experts did widely disagree on these statements and provided anwers reaching from 1 to 5. Although the average of the answers was 3.2, the diversity of results does not support a tendency.

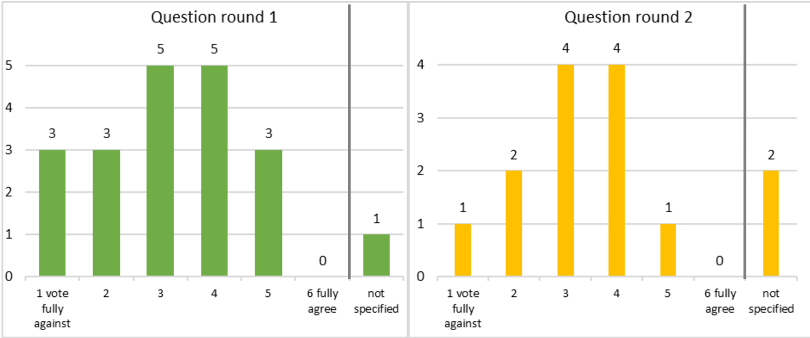

Figure A2.16**:** Question No. 16

A2.6 Other (one question)

The open question was modified in the course of the Delphi survey. In the first round of questions, experts could mention effects of digitization of agriculture on the social dimension of sustainability that were not covered in the initial questions. As three participants stated that the term digitization should be defined, as it covers a very broad spectrum of technologies and strategies. This request was followed up in the second Delphi round were experts were asked to define their understranding of the term digitization in the context of social sustainability. The results from the open question were summarized in keywords and statements. The most frequent answer was that digitization will lead to a reduction in the workload of farmers. Digitization is not seen as a panacea, but rather as a means to make farmers' work easier. One expert stated that the reputation of farmers will increase through digitization because end consumers will be able to understand the actual work of farmers and this will result in a higher appreciation for this profession. Another expert stated that, in addition to workload reduction, digitization can help to include all dimensions of sustainability, and that this would create more transparency in the entire value chain.

Appendix 3: Summary of Analysis

Table A3.1.
Summary of means and medians in Delphi study.

	Mean first round	Mean second round	Median first round	Median second round
Working hours (three questions)				
Question 1	3.8	3.8	3.5	4.0
Question 2	3.6	3.5	4.0	4.0
Question 3	3.0	2.8	3.0	3.0
Training/workplaces (five questions)				
Question 4	4.2	4.4	4.0	4.0
Question 5	4.7	4.9	4.0	4.5
Question 6	3.3	4.0	3.0	3.5
Question 7	3.8	3.6	3.5	3.0
Question 8	5.2	5.6	5.0	5.0
Data protection (two questions)				
Question 9	4.8	5.3	4.5	4.5
Question 10	3.7	3.9	3.5	3.5
Marketing (four questions)				
Question 11	5.2	5.4	5.0	5.5
Question 12	4.1	4.4	4.0	4.5
Question 13	3.4	3.6	3.5	3.5
Question 14	3.8	2.8	4.0	3.5
Barriers to digitization (two questions)				
Question 15	3.8	4.2	3.5	4.0
Question 16	3.1	3.2	3.0	3.0
Others (Open question)				
Question 17 Round 1	-	-	-	-
Question 17 Round 2	-	-	-	-