Title: The understanding of digitalisation in agriculture by small-scale farmers: The importance of clear terminology

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Abstract

New technical innovations in agriculture are changing agricultural practices. In recent years, digitisation in agriculture (DA) has become a promising megatrend, but a review of the current literature, presenting the understanding of DA by researchers, public authorities and within the private sector, demonstrates a large gap in the meaning of terms related to DA between these stakeholders, while nothing is known about Swiss farmers understandings. Following this, this study investigates their understanding of DA as term and phenomena. Furthermore, this paper aims to make sense of all the different and potentially confusing terms in use related to DA. To provide a profound basis for research on technology adoption, we combine a postal survey with a group discussion and evaluate the results gathered between January and February 2019 with managers of shared-ownership farms in the German-speaking part of Switzerland. According to the survey and discussion, farmers understand DA as systemic (this means, that is influences the farming system and is not just a single new technology) and associate the term with specific technologies, from smartphones to milking robots, without distinguishing between farm-specific and non-specific technologies. Overall, farmers have 'negative associations' as well as 'positive and neutral associations' to DA, with the former being most prominent. This refers to possible positive and negative implications when adopting digital technologies on farms. We conclude that what farmers perceive as DA differs greatly from its perception in the scientific community, while the terminology used by public institutions and private companies is much closer to the farmers' understanding of it. Our results demonstrate the importance of defining and using the phrase 'digitisation in agriculture' critically in current and future research that considers the adoption of digital farming techniques because the language used in the collection of data can influence participants' responses. Our analysis presents positive and negative implications of digital agricultural technologies. It also shows researchers' responsibility to find common understanding with farmers and the implications of these technologies for farmers, the supply chain and the consumer, but also for the society. This study also motivates responsible innovation research.

Keywords: understanding, perception, digitalisation in agriculture, Swiss farmers, smart farming, precision farming, definition, small-scale farms

1. Introduction

New technical innovations are changing agricultural practices. One of the most promising megatrends is digitisation in agriculture (DA) (DBV, 2016, p. 1) at a time when digitalisation is influencing all of society and transforming most elements of life (Tsekeris, 2018). Since the 1990s, the terms ‘digitalisation in agriculture’ (Shen et al., 2010, p. 43) and ‘digital technologies in agriculture’ have been used alongside ‘digital agriculture’. In other contexts, ‘Agriculture 4.0’, ‘precision farming’ and ‘smart farming’ are preferred. These terms may seem self-evident in research and, arguably, in the public context because they are used frequently and interchangeably, often without clarification. Further, despite the widespread use of such terminology in scientific discourse and by public institutions and private companies, how farmers understand and perceive these terms and the general phenomena of DA remains unexplored and are the aim of this explorative empirical study.

Schleicher and Gandorfer (2018) demonstrated the overarching use of the term ‘digitalisation in agriculture’ and how the use of the various concepts under it can be confusing in the study of digital agriculture. Some researchers have viewed DA as a strategy or process, while others have been confronted with the need to study it without fully grasping the term. This lack of clarity regarding the definition of digital farming likewise leads to difficulty in studying technology adoption (Lowenberg-DeBoer and Erickson (2019). As an example, de Oca Munguia and Llewellyn (2020) investigated reasons for the adoption of new technologies and innovations without defining what they meant by these concepts. Michels et al. (2019) analysed smartphone adoption by farmers, specifically capturing their use of smartphone functions and professional apps, but they did not offer any detailed definition of the terms used to analyse the decisions for adopting such technology. In a systematic review of adoption factors for precision agricultural technologies, Pathak et al. (2019) employed such a broad definition of ‘precision agriculture’ that no conclusions could be drawn about what had been adapted. Wolfert and colleagues (2017) focused on the technical dimensions of digital (smart) agriculture and discussed its implications for farm management.

Increased interest in the reasons why Swiss farmers are adopting digital technologies has raised the need for clarification of the term. As newer studies have shown, besides ambiguities in definitions, the usage rate of digital technologies by farms is still low in Switzerland (Groher et al., 2020; H. Groher T., K., Umstätter, C., 2020; H. K. u. U. C. Groher T., 2020). This indicates the need to improve understanding of the adoption of digital technologies in agriculture. Thus, in this study, we explore the adoption of digitalisation in agriculture, and in particular, the question of what exactly should be adopted as a clear and precise definition for ‘digitalisation in agriculture’. A definition for this does not currently exist, and the use of only one form of technology is not sufficient to analyse these phenomena. The

need to clarify the understanding of different stakeholders (research, policy, agricultural practice) is so great because often both scientific studies and public discourse show that people are supposedly talking about the same thing, which is not the case and creates many misunderstandings. The diversity of the phenomenon of DA can only lead to a general definition that does not capture every detail of the principle and helps to agree on a common understanding of DA in the different contexts. It can be seen as a framework for reflection. It is, therefore, necessary to know what farmers perceive to be digitalisation in agriculture. This knowledge gap provides both the motivation for this study and its research on the reasons for adoption.This following chapter introducesa brief review of the various understandings and definitions of digital farming to help frame our investigation of farmers' understanding of the concept, which is the primary aim of this investigation. In summary, the proposal for a framework on DA is presented.

2. Understanding and terminology by different stakeholders

2.1 Terminology used by researchers, the public and private sectors

This chapter aims to show how different and diverse the concepts and understandings used are. The view of research on DA it is a complex phenomenon (Voronin et al., 2019). There is much ongoing research on the technological advancement of farming systems, and different terms are employed throughout the literature. Despite the variety of terms, researchers often fail to define or describe the terms that they use in their studies. As an example of this, Phillips et al. (2019) use of the term *'digital technologies in agriculture'* referred to a range of new technologies and big data applications, while the term *'smart farming technologies'* (Kernecker et al., 2019, p. 1) is widely used in parallel with *'digital farming'*, *'digital agriculture'* and *'Big Data applications'*. For Jakku et al. (2018, p. 2), *'Big Data applications'* were not part of *'digital agriculture'*, and they used *'smart farming'* and *'digital farming'* synonymously.

The situational and contextual uses of the various terms also vary. Fielke et al. (2019) stated that the term *'digital agriculture'* (preferred in Australia and New Zealand) and *'smart farming'* (preferred in the European Union) are used in different spatial contexts (Robertson et al., 2016; Wolfert et al., 2017). Similarly, 'farming in the digital era' was used by Walter et al. (2017), although the authors recommended the use of the term 'smart farming' only connection with networking and institutions (i.e. markets and policies). El Bilali and Allahyari (2018) referred to the importance of *'information and communication technologies (ICT)'* in this context, and, according to Petkovic (2019), ICT applications in agriculture can be described as an *'e-agriculture system'*, defined as the exponentially increasing use of ICT in

agriculture (Walter et al., 2017, p. 6148). This leads to the systemic character of digital technologies in agriculture.

Several definitions imply additionally a systemic and networked character. For example, *'farm management information systems'* was used by Fountas et al. (2015, p. 40), they were developed to the need for communication and data transfer between databases, and to meet the requirements of different stakeholders. The definition provided by Shen et al. (2010, p. 43), *'[a] digital agricultural system is a database'*, focused on the data aspect, as did that of Wolfert et al. (2017), who reviewed big data in smart farming. More than two dozen definitions of *'precision agriculture' (PA)* have been identified over the years. In 2018, the International Society of Precision Agriculture sought a definition for PA, which was attained through a vote by members (International Society of Precision Agriculture, 2019). This vote added a new layer to the definition by defining PA not just as a product but a strategy. The term *'digitisation'* shows development towards more complexity.

More recent research has considered an area for a long time only outside agriculture, *'blockchain technologies'* to be part of digitalisation in agriculture (Ge et al., 2017; Kamilaris et al., 2019). Due to the high financial cost of some new digital technologies, financial technology and digital marketplaces have also been gaining attention in agricultural studies through their involvement in the digitalisation of agriculture (Anshari et al., 2019). These elements are often outside of farms and occupy a place further along the supply chain.

Besides research, the construct of *'digitalisation in agriculture'* is also in use in the public and private sectors. The German Farmers' Association uses it and calls it a 'megatrend' (DBV, 2016, p. 1). The German industry association for the digital economy, Bitkom, has published a position paper on DA that lists individual technologies and leaves the term open (bitkom, 2016). *'Agriculture 4.0'* was used in the political documents of the World Government Summit (Clercq et al., 2018, p. 1). Private companies use *'digitalisation'* based on their own understanding of it and mainly use terms related to *'precision farming', 'digital farming'* and *'smart farming'* (agrocares, 2019). The authors concluded that 'Digital farming is integrating both concepts – precision farming and smart farming'. BIOPRO Baden-Württemberg defined precision farming as follows: '"*Precision farming*" is the targeted management of agricultural land using smart electronics' (Giesler, 2019). In a study on digitalisation in agriculture, the accounting firm PricewaterhouseCoopers assessed the various terms as hierarchical (PricewaterhouseCoopers GmbH, 2016), with precision farming deemed an information-based approach and smart farming a knowledge-based approach.

While many terms are subordinate under or part of digitalisation in agriculture, in Switzerland, a project was created to design rules for the sustainable development of digitalisation. Different stakeholders developed and signed the *Charta zur Digitalisierung der Schweizer Land- und Ernährungswirtschaft*' (*Charta zur Digitalisierung der Schweizer Land- und Ernährungswirtschaft*, 2018). According to the Charta, the 'digitalisation of the Swiss agri-food industry' (*Charta zur Digitalisierung der Schweizer Land- und Ernährungswirtschaft*, 2018) refers to the collection, storage and processing of data and their use in digital format. The Charta community is limited to the data component of DA and does not provide a definition. Furthermore, a report by the European Parliament on precision agriculture and the future of farming in Europe defined precision farming as 'a modern farming management concept using digital techniques to monitor and optimise agricultural production processes' (Daheim, 2016, p. 4). More generally, and outside agriculture, 'digitisation' is defined, but 'digitalisation' is not (Bloomberg, 2018). According to *Gartner's IT Glossary*, '[d]igitization is the process of changing from analogue to digital form' (Gartner, 2019). As terms and understanding are not clear in general, it is not surprising that there is no conceptual clarity in the sector of agriculture.

2.2 Framework on the understanding of digital farming

Many concepts are associated with the term 'digitalisation' in agriculture. As a result, complex agricultural technologies and functions will likely continue to expand the meaning of this term due to changing technical opportunities; therefore, it is not likely to remain constant, and Lutz (2017, p. 429) characterised the term as 'evolutionary'. We propose a conceptual framework of digitalisation in agriculture (Figure 1) that was developed deductively based on the reviewed literature. The system as a whole can be understood as the process of digitisation, whereas individual parts are involved in digitalisation. The framework shows the development of individual technologies and software towards systemic understandings. The model can be applied not only to the use of a single technology but also to an entire farming system. One outstanding feature of this model is its recognition of change. At the same time, the development of technologies, options for analysis, knowledge and societal and legal frameworks undergo major changes and influences; thus, the definition of DA and the understanding of individual actors.

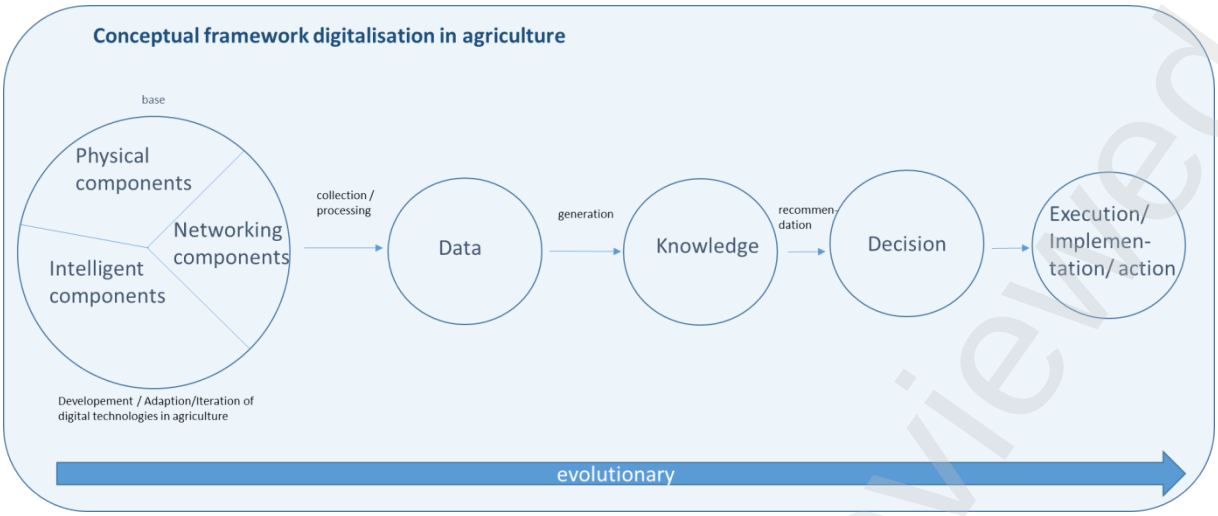

Figure 1. Conceptual framework for digitisation in agriculture (source: author)

3. Materials and methods

We combined a postal survey with a group discussion to explore farmers' understanding of digitalisation in agriculture. We have chosen this method, to give the farmers the possibility to reflect on their understanding of DA and answer the survey by themselves and discuss the important topics, resulting from this survey in a group discussion to trigger deeper reflection processes in the group to gain a more accurate and shared understanding of farmers' perspective. The group discussion was developed from the results of the survey and the literature. Given the small number of respondents, the results are only tentative, but they still provide a rich picture of the wide variation of understanding of digital agriculture among Swiss farmers. To assess how farmers perceive the term 'digitalisation in agriculture', we developed a short questionnaire with open, semi-open and closed questions, based on current literature with 17 questionnes (while some contained under items)The farmers had about 20 minutes to fill in the survey. The specific questions can be found in the results section. In January and February 2019, the questionnaire was sent to all managers of shared-ownership farms in German-speaking parts of Switzerland (n = 788). Shared-ownership farms were chosen because, in Switzerland, they consist of small family farms with rather suboptimal conditions for adopting cost-intensive digital technologies. Still, there is evidence that such farms are suitable for digital technology adoption, as capital and knowledge can be shared among them (Reichardt et al., 2009). The open questionnaires were analysed using content analysis (Mayring, 2016), while quantitative description analysis was used or the closed questions.

The remainder of the study data were obtained through a group discussion with farmers of the shared-ownership farms that was facilitated by the World Café method (Brown, 2005).

The World Cafe is a method which makes use of an informal cafe setting for participants to explore an issue by discussing it in small table groups. Discussion is held in multiple rounds of 20-30 minutes, with the cafe ambiance intended to allow for more relaxed and open conversations to take place. The discussion was held during an annual business community meeting on digitalisation in agriculture that was organised by Agridea and Agroscope in March 2019 at the Federal Agricultural Research Station Agroscope. It consisted of 24 participants from the sample group described above.

We deliberately did not define the term 'digitalisation in agriculture' in the questionnaire so that we could better understand how farmers understood the term, rather than them reacting to the researcher's definition. Two open questions are analysed in this paper. In the first, the respondents were asked to freely associate the term 'digitalisation in agriculture' (*What comes to mind when you hear 'digitalisation in agriculture'?*); in the second, they were asked about farming technology use (*What digital technologies do you use in your business community?*). The answers for both questions were analysed using MAXQDA software Version 2018 for qualitative content analysis (Mayring, 2015). Answers to the closed question analysed in this paper (*What is your attitude towards digitalisation in agriculture?*) were recorded on a five-point Likert scale. Polar question format was used for questions about actual and future digital technology use on the respondents' farms. The standardised Affinity for Technology Interaction instrument (ATI) was used to measure farmers' affinity for technology and their interaction with it (Franke et al., 2018, p. 456).

Thirty-four managers of Swiss farm co-operatives answered the postal survey, giving a response rate of about 4%. They had an average age of 42 years (range: 26–61 years). Of the 788 farmers invited to the World Café at the annual business, community meeting organised by Agridea and Agroscope, 24 participated. The low response rate is discussed in more detail below. There is little data on the 24 participants, except that they were managers of Swiss shared-ownership farms. The average size of these farms in Switzerland is 21.14 hectares (Bundesamt für Landwirtschaft (BLW), 2021).

4. Results

4.1. Swiss farmers' general understanding of digital technologies in agriculture

The respondents' understanding included more topics than the relationships between agriculture and technology or software, and they demonstrated an appreciation for the topic's complexity. Figure 2 shows a word cloud with topics that the farmers associated with digitalisation in agriculture. The strength of the font is proportionate to the frequency with which each word was mentioned. In addition to mentioning digital technologies, software used and digital records, the topic of 'control, traceability and link' was mentioned most frequently. This reveals that farmers first perceive technologies individually and also the networked character of digitisation in agriculture.

Figure 2. A word cloud of uncategorised responses to the question *'What comes to mind when you hear "digitalisation in agriculture"?'* obtained through a postal survey of managers (n = 34) of shared-ownership farms in German-speaking parts of Switzerland.

Table 1. Categorised responses to the question '*What comes to mind when you hear "digitalisation in agriculture"?*' obtained through a postal survey of managers (n = 34) of shared-ownership farms in German-speaking parts of Switzerland.

Main Code	Subcode	Frequency
Technology/software	Definition uncertainty	1
	Digitised agricultural machinery	16
	Software	11
Positive and neutral associations	Progress	4
	Simplification	5
	Networking	1
	eGovernance/digital records	7
	Digitalisation as a general development in society	1
Negative associations	Lifelong learning/own initiative*	1
	Control/traceability/link	8
	Investment costs	2
	Bad implementation/error prone	2
	Network infrastructure	2
	Higher time requirement	5
	Complicated	2
	More stress/overtaxing	2
	Data uncertainty[1]	1
	Antipathy	3
	Risks[2]	1

* *Can also be understood positively, although the farmer's answer clearly gave a negative connotation.*

It was clear that the farmers tended to perceive DA as systemic (Table 1). As mentioned above, farmers most frequently mentioned the 'control, traceability and link' behind the different technologies and software, as well as the mention of 'network'.

Regarding the associations that the farmers formed in response to the term 'digitalisation in agriculture' (see Table 1), they appeared often to think of a single form of digitised

[1] 'No existing regulations for handling and owing data'

[2] 'New big risks not specified'

agricultural machinery, as indicated by the frequent appearance of concepts in the 'technology/software' category. Besides technology, other topics were divided into 'positive and neutral associations' and 'negative associations'. The negative associations, strikingly, outweighed the positive and neutral associations.

3.2. Understanding Swiss farmers' usage of and involvement with digital technologies

After obtaining a general understanding of the term 'digitalisation in agriculture', it was necessary to elicit more specific information from the respondents regarding their usage of and their involvement with digitalisation in agriculture. It was previously unknown how farmers perceived their usage of digital technologies in agriculture. Regarding the survey question '*Do you use digital technologies?*', 69% of respondents said 'yes'. To the question '*Do you plan to acquire new or additional digital technologies in the future?*', 41% of respondents answered positively. The responses by farmers who stated that they did not use digital technologies were not relevant to a later survey question about the use of specific digital technologies, except for those who disclosed that they used *WhatsApp*. Consequently, digital technologies were cited by 69% of respondents (Table 2). When asked '*What technologies do you think are part of digitalisation on your farm?*' (see Table 2), there was no clear and consistent view of how the farmers understood the term 'digital technologies'. The farmers listed technologies that could be separated into three distinct groups: digital technologies/general-use software, digitised agricultural machinery and agricultural software. Most farmers used a mobile phone and therefore felt that they were taking part in the digitalisation of agriculture. They differentiated between general and operational technology and its uses, but most of the farmers perceived some technologies as having a concrete purpose. The farmers were already using digital technologies, including equipment such as milking robots or software like AgroTwin, on their farms (Table 2). Furthermore, our results show that 67% of the farmers who were already using digital technologies answered 'yes' to the question '*Do you plan to acquire or use new or additional digital technologies in your shared-ownership farm in the future?*', while only 10% of the non-users intended to do so.

Table 2. Categorised responses to the question '*What digital technologies are you using?*' obtained through a postal survey of managers (n = 34) of shared-ownership farms in German-speaking parts of Switzerland.

Digital technologies/ general-use software	Digitised agricultural machinery	Agricultural software
Mobile phone	Automated watering for animals	E-field calendar IPS
Smartphone	Automatic feeder	SmartCow
Desktop computer	Tractor with GPS	Agate
Laptop	Tracking systems	Cantonal data collection
GPS	Milking robot	Treatment journal
Camera	Rutting recognition	Beef Net
Photovoltaic system	Herd management	AgroTwin
Biogas plant technology	Drone DJI Mavic (for watching cattle in the Alps)	Structured data collection
Software		Animal movement database
Apps		Time and performance recording
E-banking		Reservation systems
Email		
WhatsApp		

Farmers' answers to the World Café question '*What counts for me as the "digitisation of agriculture"?*' resulted in statements that resembled the answers to the questionnaires; however, some additional understanding was obtained regarding in-depth perception during the group discussions (Table 3). Through the group discussion, the process of thinking about the technology was evaluated in exchange, and the farmers mentioned additional 'digitised agricultural machinery', such as 'precise control of application rates'. Furthermore, the farmers discussed in detail the essence of digital technologies in general and thus understood very well the character of digitisation in agriculture. They talked about the use of sensors and robotics, the necessity for and application of the Internet and also the great importance of data and its exchange.

Table 3. Additional examples within the three categories of responses to '*What counts for me as the "digitisation of agriculture"?*' obtained during a group discussion (n = 24) with managers of shared-ownership farms in German-speaking parts of Switzerland.

Digital technologies/ general-use software	Digitised agricultural machinery	Agricultural software
Sensors	Precise control of application rates	
Robotic	Sprinkling	
Internet	Digital weather station in the orchard	
Data exchange		
'Paperless' office		
Data		

311

312 The results (see Tables 2 and 3) indicate that the managers used a combination of
313 agricultural technologies and direct payment administration software. They indicated that
314 they perceived themselves as participating in 'digitalisation in agriculture' and that they were
315 knowledgeable on the topic. Conversely, research and administrative uses of the term
316 implied more sophisticated concepts, as were referenced in the introductory chapter.

317

318 ***3.3. Swiss farmers' attitudes towards digitalisation***

319 To understand these complex phenomena more precisely, over and above the perception of
320 the concept, we asked the farmers about their attitudes towards digitalisation using the
321 survey. Responses to the question '*What is your attitude towards digitisation in agriculture?*'
322 were recorded on a five-point Likert scale (Figure 3). About 50 per cent of the respondents
323 demonstrated a positive attitude towards digitisation in agriculture. This result contradicts the
324 mostly negative associations formed by the farmers (Table 1), resulting from the group
325 discussion and indicated the need for a critical examination of the topic.

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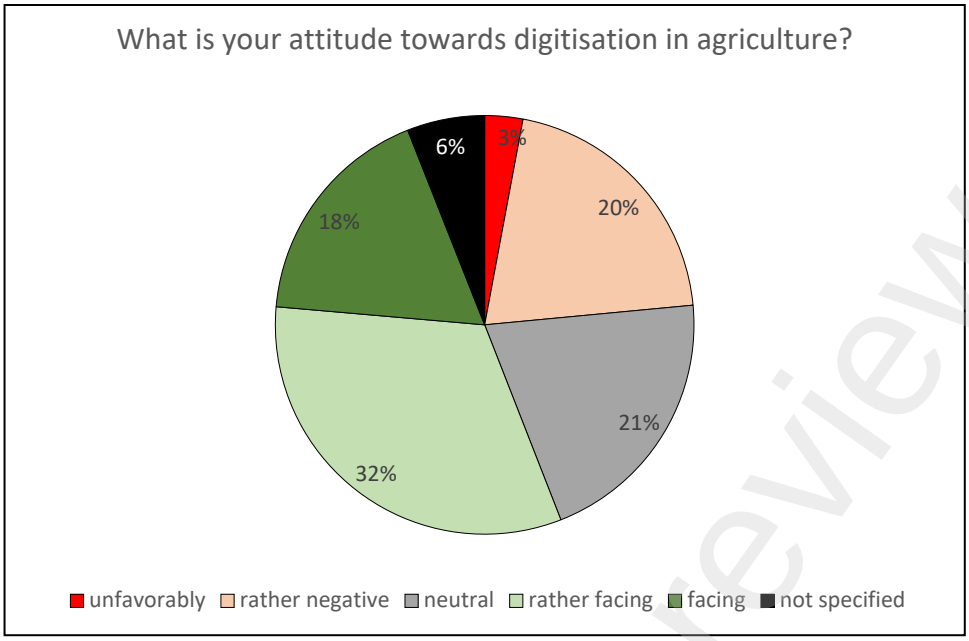

Figure 3. The attitudes of farm managers towards digitalisation in agriculture, obtained through a postal survey of managers (n = 34) of shared-ownership farms in German-speaking parts of Switzerland.

The results demonstrate that attitudes towards digital technologies coincide with usage (Table 4). The farmers who stated that they did not use digital technologies had a negative or somewhat negative attitude towards them.

Table 4. Comparison of attitudes towards and use of digital technologies in agriculture obtained through a postal survey of managers (n = 34) of shared-ownership farms in German-speaking parts of Switzerland.

Attitude towards digital technologies in agriculture	Usage of digital technologies (percent)
Not specified	0
Unfavourable	0
Rather negative	29
Neutral	86
Rather favourable	91
Favourable	100

In addition to this connection between attitude and usage, one farmer with a negative attitude towards technology stated that he used a milking robot; another stated that they used email, while one more mentioned that they used WhatsApp. The farmers with a neutral or somewhat positive attitude tended to use several digital technologies. In the group of farmers

who had a favourable attitude towards technology in farming, most of the technologies they listed were used in combination, and these farmers would even use experimental new technologies. Since its approach is explorative, this study can only present correlations and not show causality. The correlation between attitude and current usage of digital technologies was significant (Spearman correlation 0.657**), as it was between attitude and future usage (Spearman correlation 0.682**). We also saw a positive correlation between current and future usage (Spearman correlation 0.516**).

4. Discussion

The term ‘digitalisation in agriculture’ is a complex concept, and the surveyed farmers’ understanding of it offered important insights into why this is the case. Of them, 69 per cent said that they used digital technologies and another 41 per cent indicated that they would adopt them in the future or add to their existing technology use. Some scholars would say that agriculture is already digitised, but other studies have shown that the most advanced technologies are not in widespread use (Long et al., 2016). This contradiction suggests that understanding of the concept varies between farmers and researchers. Studies that have looked at levels of digitalisation in agriculture have reported very low levels of adoption in Europe, and especially in Switzerland (Groher et al., 2020; H. Groher T., K., Umstätter, C., 2020; H. K. u. U. C. Groher T., 2020); therefore, a utilisation rate of almost 70 per cent among the current study’s respondents was immediately surprising.

However, upon closer examination of how farmers see themselves in terms of digitisation in agriculture, this high level of use became both understandable and meaningful. When farmers use a smartphone or file their tax return online, they perceive themselves as participating in the digitisation of agriculture. Many farmers referred to smartphones or other mobile phones in their answers to the question about technology use. During the group discussion, the farmers insisted that mobile phones fell under digital farming because they were digital and had influenced farm work significantly. One farmer said that before he had access to a mobile phone, he had to return to the farm to coordinate with his colleagues. ‘Little’ or ‘common’ digital technologies are already impacting work in agriculture and are therefore perceived to be part of its digitisation. These results emphasize the need to endorse how actors engaging in the praxis of farming understand the digitisation of agriculture and relevant technologies. An emphasis on the praxis of digital transformation is crucial.

This understanding fits with the finding that farmers do not distinguish between the use of farm-unspecific and farm-specific technologies (Table 2). Michels et al. (2019) studied the use of the more advanced version of the mobile phone—the smartphone—in German agriculture. They found that the technical development of smartphones was important even though farmers still considered more rudimentary mobile phones useful in agriculture. Here, too, it was evident that research is often focused on the latest technologies (e.g. farm management information systems Ammann et al., 2022), while farmers continue to consider older technologies as innovations. However, the farmers understood innovation to comprise a broad spectrum of technologies, which coincides with the various definitions and concepts of digitalisation in agriculture and the research and public sectors. At the same time, it is

apparent that the farmers were aware of digital technologies, used many types of digital machinery on the farm, used a wide variety of plant-specific software or participated in e-governance programmes. They were engaging with the concept and already adopting and using some technologies in their work.

The level of knowledge about the digitalisation of agriculture varied between individual farmers. Some farmers were only just becoming acquainted with the subject, while others were already deeply involved in it. For the sake of clarity, none of the individual response profiles presented here could demonstrate this. While some of the definitions outlined in the introductory section place the digitisation of agricultural data and its use at the forefront or consider digitisation to be a process rather than a single technology (e.g.Finger et al., 2019), the farmers indicated that they primarily viewed it as involving individual technologies. Their responses suggested that they did not perceive a change in the entire production system during development, nor did they perceive digitalisation in their sector as a process or strategy. In part, the farmers in the study group perceived the networking and the central position of data. This perception of individual farmers is already getting closer to the nature of DA (refered to e.g. by Bernhardt et al., 2021). Farmers start dealing with the networking nature of digitalisation in agriculture and need to build experience and knowledge. It is also evident that the degree of knowledge about the topic was very different between farmers, and their understanding of it was therefore different, which concurs with the findings of Kabir (2015) and Eidt et al. (2012). According to the innovation adoption literature (e.g. Sun & Bosch, 2013)and the results of the group discussion the understanding t, in addition to knowledge, was influenced by various other factors like attitude and finance.Basically, the farmers primarily saw DA as labour-economical and thus viewed it on a practical level, while research has tended primarily to take a more holistic view to better capture the phenomenon as a whole (Fountas et al., 2015; Gandorfer et al., 2017; Kernecker et al., 2019; Lutz, 2017; Schleicher & Gandorfer, 2018). It is interesting to note that the majority of the surveyed farmers were positive about digitisation in agriculture, which agrees with Kabir (2015) results, yet they mostly expressed negative attitudes regarding the implications of its implementation. Their responses indicated that they saw both the benefits and the potential harms of these technologies. A recent research trend, responsible innovation research (e.g. Eastwood et al., 2019; Van der Burg et al., 2019), deals with the implications of digital technologies in agriculture. Van der Burg et al. (2019) referred to the implications of these technologies in three groups: data ownership and access, distribution of power and impacts on human life and society. As this paper focuses on farmers' understanding, we will not discuss the ethical impacts themselves, but the ones that are already perceived by farmers.

When making associations with digital farming, the farmers already saw implications in the three named areas (Van der Burg et al. (2019). They were aware of risks, the networking character, the central position of data, the unclear handling of data and lack of legal safety, as well as the impact the characteristic of farm work and network that, for example, lifelong learning is necessary. In this research, the gap in understanding between research, policy and farmers came to be expressed. This motivates the use of responsible innovation research to combine the different perspectives and be able to develop these new technologies in a sustainable way. As recent papers (Linsner et al., 2021; Wiseman et al., 2019) have referred to the role of privacy in digitalisation and advised of the urgent need to raise data awareness in the farming sector, we should discuss our results concerning the perception of data in more detail. The surveyed farmers had already perceived that the networking character and data use is a basis or DA and associated negative the possible control, traceability and accessibility of data by different stakeholders, as federal government or other supply chain members. Linsner et al. (2021) explained that the fear of sharing data is also a limitation for DA technology adoption, which in parallel affects the work processes of a modern farm and changes the profile of professional farmers. The authors also referred to the rising dependency of farmers and conflicts of interests regarding privacy and transparency. Building on our results, we found the same topic and impact of DA technologies by our sample farmers. These new technologies were closely interwoven with data usage, privacy and transparency and impacted farm practices, the supply chain and the power relations within it more than was previously done by technology innovations. Swiss farmers' perception of that had already grown, which may explain the negative attitude of farmers towards DA technologies and their decision to use them. The research community has just started to understand this topic, even if the data topic is working in the field and impacting farmers and other stakeholders beyond the topic of data. Furthermore, the power balances between different stakeholders are changing in the face of DA, and this will affect the entire farming system.

One limitation of the study is that few of the farmers in the quantitative part were prepared to offer us their insights. According to the too small response rate for the questionnaire, we assume that we have a bias and rather have women farmers in the sample who are interested in digitalisation. Even though several topics emerged in this exploratory sample, it can be assumed that more topics would emerge in a larger sample. The low participation in the survey and in the conference can be interpreted differently. On the one hand, the topic is omnipresent and overloaded with frequent events on the subject; on the other, there is evidence that farmers are not proactively addressing this issue. As far as the validity of the results is concerned, all participants filled out the completed questionnaires conscientiously,

and the participating farmers at the meeting approached the topic with an open and interested mind-set. The survey responses of the 50 per cent with positive feelings toward DA also reflected this mindset. Moreover, as our study group indicated, 69 per cent of the respondents did use digital technologies on the farm; therefore, we base our conclusions on responses from an appropriate number of farmers to answer the question of the perception of digitalisation in agriculture. Of course, it must be taken into account that the community of the survey group influenced the responses, and, together, they provided a more comprehensive picture than that of a single farmer. From further studies with a larger sample, it will be possible to further differentiate the perceptions of farmers. Another factor that needs to be analysed in the future is the ability of farmers to acquire new skills and their and strategies for doing so. However, the level of knowledge and the perception of DA between farmers is very different. It is important to keep this observation in mind in research on technology adoption because knowledge and perception influence farmers' decision to adopt (or not) new agricultural digital technologies (Eidt et al., 2012; García-Cortijo et al., 2019; Higgins et al., 2017).

Following the discussion of data privacy, we recommend increasing awareness of privacy in terms of digitalisation in agriculture. For the successful adoption of digitalisation, according to Linsner et al. (2021), study of data perception among German small-scale farmers, it is important to establish mechanisms that make relevant data accessible to all without exposing the operational data of individuals to misuse and leaving individuals behind. As our study provides hints that the topic of data usage is also important for Swiss farmers, we recommend a representative quantitative survey to gain more insight into the perception of data privacy and usage by Swiss farmers. As the farmers in this study were specifically small-scale farmers in Switzerland, they stay in the middle of the supply chain and in a weaker position according to commercial purchases or suppliers. Therefore, it is crucial for them to retain control over access to and the flows of their farm data.

Further research is also recommended on the perception of digitisation in agriculture. How farmers perceive it differs greatly from those in the scientific community. Current research on the adoption of digital farming mainly concerns technologies with networking features that are frequently still in development and not available for use by farmers. At the same time, farmers' understanding is less varied and based on the small number of technologies they use (Barrett & Rose, 2020). Researchers must examine and use the term 'digitalisation in agriculture' critically. To conduct further and more detailed studies on the adoption of digitisation in agriculture, we must be aware of exactly what the respondents are responding to and, therefore, what the results are telling us. For example, research on very specific

individual technologies (e.g. Hansen, 2015) often fails to draw any conclusions about the overall phenomenon of digitalisation in agriculture. Using very generic questions ran the risk that farmers understood fundamentally different things, and thus their answers were not comparable. Perhaps is worthwhile to keep in mind the rules of knowledgeable communication: to ask what the other person thinks and how they understand the concepts at play so as not to end up in a situation whereby everyone knows what *they* mean, but no one knows what the *other* means.

5. Conclusion

We fully appreciate and endorse the emphasis on the understanding of the term, concept or phenomenon of digitalisation in agriculture concerning the understanding of the farmers observed in this study. However, our commentary provides several sound reasons that may explain the confusion surrounding it and related terms. Currently, there is no common understanding of the specific meaning of the terms used by researchers, public organisations, administrations and the farmers themselves. We see very clear indications in the group discussion and also in the quantitative sample that the understanding of farmers is very diverse. Due to the small survey response rate, it is not possible to say to what extent the individual positive aspects are represented in Switzerland. We strongly recommend that researchers do not forget the perspectives of farmers, especially in the context of direct surveys, and particularly regarding attitudes and determinants. The research and academic community can gain an understanding from this study of the practitioners working on farms. In each case, the terms they use must be chosen with precision and should be depicted in surveys visually to ensure that farmers and researchers have the same concept in mind. Moreover, the advancement of digital technologies in agriculture, understanding of the development of the new farming dimension and process of adoption need to keep in mind the complexities of different stakeholder perspectives on this topic. This study extends the knowledge about how farmers understand digitalisation in their sector and the complexity of the phenomenon. Through its findings, this study also aims to raise awareness of the use of terminology and the implications of digitisation in agriculture. This research shows farmers' awareness of the impacts of digital technologies to be both positive and negative, and identifies the different levels of understanding between different stakeholders (farmers vs researchers, policy-makers and enterprises). Therefore, this research also motivates responsible innovation research to anticipate the possible impacts when developing and introducing new technologies, as our research sheds light on the possible power imbalances resulting from the use of data from DA.

Declaration of Competing Interest

The authors declare no conflict of interest.

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