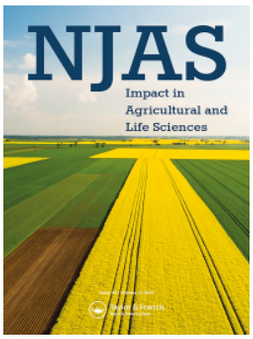

NJAS: Impact in Agricultural and Life Sciences

ISSN: 2768-5241 (Online) Journal homepage: www.tandfonline.com/journals/tjls21

The impact of digitalization on the public opinion of fruit farming: Stakeholder perspectives in Germany

Kirsten Gaber, Christine Rösch & Claudia Bieling

To cite this article: Kirsten Gaber, Christine Rösch & Claudia Bieling (2025) The impact of digitalization on the public opinion of fruit farming: Stakeholder perspectives in Germany, NJAS: Impact in Agricultural and Life Sciences, 97:1, 2508139, DOI: 10.1080/27685241.2025.2508139

To link to this article: https://doi.org/10.1080/27685241.2025.2508139

Published online: 22 May 2025.

NJAS: IMPACT IN AGRICULTURAL AND LIFE SCIENCES
2025, VOL. 97, NO. 1, 2508139
https://doi.org/10.1080/27685241.2025.2508139

Taylor & Francis
Taylor & Francis Group

The impact of digitalization on the public opinion of fruit farming: Stakeholder perspectives in Germany

Kirsten Gaber [a,b], Christine Rösch [a] and Claudia Bieling [b]

[a]Karlsruhe Institute of Technology, Institute for Technology Assessment and Systems Analysis, Karlsruhe, Germany; [b]Institute of Social Sciences in Agriculture, Societal Transition and Agriculture (430b), University of Hohenheim, Stuttgart, Germany

ABSTRACT

Digitalization in fruit production can create significant social and environmental impacts through on-farm efficiency gains and by enabling transparent communication from farm to fork. As societal criticisms currently challenge the future of agricultural practices, it remains unclear how the public opinion of fruit production will change through digitalization. This study explored the perceived impacts of digitalization on the public attitude towards fruit production by investigating the views of stakeholders along the fruit value chain, using the Lake Constance region in Southern Germany as a case study. Of the 33 interviewed stakeholders, 73% believed that digitalization could impact the public opinion of fruit products and production methods. Positive impacts were anticipated more frequently than negative. Two clear pathways through which this change could occur emerged: through (1) on-farm usage of digital tools or (2) increased transparency along the value chain. Nevertheless, stakeholders expressed concerns that the foundational knowledge about agricultural practices in society is currently too low, challenging the potential benefits of digitalization to improve public opinion. The described impact may be contingent upon the narrative surrounding the use of digital technologies and their impacts. Prioritizing honest communication about fruit production and building trust towards farmers should be central goals of digitalization.

ARTICLE HISTORY Received 27 September 2024; Revised 15 January 2025; Accepted 15 May 2025

KEYWORD Digitalization; fruit production; case study; Germany; public opinion

1. Introduction

As the basis of all primary production, agriculture is facing major challenges to meet the increasing demands of a growing world population. The goals of food production and environmental protection can conflict with each other, as agriculture also has a significant responsibility for preserving key environmental assets such as soil, water, climate and biodiversity. Moreover, societal

CONTACT Kirsten Gaber Kirsten.gaber@kit.edu

criticisms are challenging agricultural production practices. Concerns primarily surround environmental and labourer- and animal-welfare aspects of today's production methods (Balmann, 2016). A disconnect between consumers and farmers with the continued advancement of industrialized agriculture has been observed (Duncan & Broyles, 2006; Zimbelman et al., 1995) and the resulting deficit in agricultural knowledge or literacy has led to an increase in concerns among consumers (Rumble & Irani, 2016). Deficient understanding about production methods could lead to mistrust, misguided public support for political campaigns, and a lack of understanding of price politics, which together threaten the future of farming (Igo & Frick, 1999).

Digitalized technologies are anticipated to mitigate both environmental and societal challenges in the agri-food sector (Nesheim et al., 2015; Wolters et al., 2021). Impacts created through the digital transformation of agriculture, such as greater environmental efficiency and increased transparency along the value chain, could alter the public image of agricultural production methods. As improved transparency and communication of agricultural production methods can positively influence consumer attitudes and trust (e.g. Fu et al., 2023; Rumble & Irani, 2016), there is hope that the transparency of production processes and traceability that can be simplified through digitalization will create trust and increase appreciation of agriculture (Deutsche Landwirtschafts-Gesellschaft, 2018). Digitalization can be helpful in the communication between the agricultural sector and the consumer, in the development of direct marketing and cooperation models, and in the recording and presentation of process quality (Bund für Umwelt und Naturschutz Deutschland, 2019). For instance, blockchain-based systems and, more significantly, the labelling of blockchain technology use on products, have been found to have a positive effect on purchase intention via perceived product quality (Treiblmaier & Garaus, 2023). The use of blockchain technologies in agriculture, such as through the framework for securing agriculture-related data as suggested by (Kassanuk & Phasinam, 2022), may enable safer recording of farming data as well as public access to the data, which could function to positively influence public opinion of agricultural products and practices through increased transparency to the consumer (Yap et al., 2023).

Still, critical attitudes towards farmers and farming practices may not equate to an overall lack of societal acceptance, nor do they necessarily stem from a lack of knowledge on agricultural production, as critical attitudes have also been observed to grow with increased societal knowledge (Landwirtschaft, 2021; Sonntag et al., 2021). Consumers have expressed negative attitudes regarding technical progress in the agri-food sector, as they are unfamiliar and therefore uncomfortable with the concept and have often perceived such progress as being unnatural (Mohr & Höhler, 2023; Pfeiffer et al., 2021; Zander et al., 2013). Consumers generally exhibit a preference for "naturalness" regarding farming and

food systems (Román et al., 2017), which works in favour of organic farming and products, as they are perceived as more natural when compared to non-organic production methods (Kühl et al., 2023; Lang & Rodrigues, 2022; Zander et al., 2013).

Critical views on agricultural production are widespread among the German population (Pfeiffer et al., 2021; Weible et al., 2016; Zander et al., 2013). German farmers are portrayed as pioneers of digitalization (Bitkom & Bauernverband, 2020) and the agricultural sector has been credited for leading national digitalization (Rentenbank, 2018). The general attitudes of German individuals towards technology (e.g. technophilic or technophobic) strongly determines the acceptance or rejection of farming systems that use digital farming technologies (Wilmes et al., 2022). Overall, German citizens are in favour of the use of digitalized technologies in agriculture (Spykman et al., 2022; von Veltheim & Heise, 2021), particularly as a means to reduce agrochemical use (Spykman et al., 2022). Still, Pfeiffer et al. (2021) speculate that criticism of agriculture in Germany is so widespread that potential benefits from digitalization are unlikely to significantly increase public acceptance of agriculture.

Horticulture as an agricultural sector is not immune to these issues related to public perceptions. This sector faces its own unique environmental and societal challenges (e.g. Chemnitz et al., 2022; Marinoudi et al., 2021). Additionally, societal acceptance has been found to be more favourable for organic fruit than for non-organic (e.g. Cerda et al., 2012; Yue et al., 2009). The development of digital technologies for fruit cultivation is progressing, including autonomous harvesting (e.g. Baeten et al., 2008; J. Zhang et al., 2024), deep learning and AI for the detection of fruit characteristics (e.g. Barbole et al., 2022; Kodors et al., 2020; Miranda et al., 2023; Nordmark et al., 2021), smart sensors and modelling for improved efficiency in apple production (e.g. Siefen, 2021; N.; Siefen et al., 2023; Biegert, 2022), and unmanned aerial vehicles and robots for fruit farm surveillance and management (e.g. Adarsch et al., 2018; Stefas et al., 2016; C. Zhang et al., 2021; Q. Zhang et al., 2019). Still, the impact of digitalization on the public perception of fruit production has yet to be studied.

It is evident that different views exist on the relationship between digitalization, agricultural production, and consumers' perceptions and expectations to address sustainability challenges. Considering the various stakes at hand in the digitalization of agriculture, stakeholders along agricultural value chains offer valuable insights from their areas of expertise. To this end, the research questions that guided this study are as follows: (1) how do stakeholders perceive the public opinion of fruit farming? (2) How do stakeholders believe that the use of digitalized technologies in fruit farming (general, meaning regardless of production system, and organic) will impact the public

opinion of the products and production methods, and how do they believe that different technologies could create this impact?

2. Materials and methods

This study uses a qualitative, open, and exploratory case study approach. The authors conducted semi-structured interviews with stakeholders along the fruit value chain in Southern Germany and sought to understand what stakeholders actually consider when asked about digitalization without guidance from the interviewers. The chosen methodology is best suited to answer the research questions, as it allowed themes to naturally emerge based on the stakeholders' individual perceptions and phrasing. The themes were subsequently identified during the qualitative analysis of the interviews.

2.1. Region of study

The region of Lake Constance in southern Germany is the second-largest fruit growing area in the country (Bundesministerium für Ernährung und Landwirtschaft, 2016; Kösler, 2023). The geographical region of Lake Constance includes the counties of Konstanz, Bodenseekreis, and Ravensburg in the state of Baden-Württemberg, as well as the county of Lindau in the state of Bavaria (Genuss Bayern, 2024). Mild temperatures and the proximity to the Lake of Constance have enabled agriculture to thrive for generations. Small- to medium-sized family farms produce cereals, potatoes, corn and speciality crops, such as fruit, vegetables, and wine (Grimminger et al., 2018). Just over 1017 fruit farms can be found across all four counties in the Lake Constance region (Bundesministerium für Ernährung und Landwirtschaft, 2016). Nearly 75% of the regional tree fruit area (10344 ha) is dedicated to apple cultivation (7692 ha) (Baden Württemberg, 2022a, 2022b, 2022c; Bayerisches Landesamt für Statistik, 2018). In the state of Baden-Württemberg, the organic-certified cultivation area for fruit is greater than the average organic-certified cultivation area for total agriculture at 18% and 12%, respectively (Kösler, 2023). While nearly half of all national fruit farms are categorized as small at less than 20 ha hectares (Statistische Ämter des Bundes und der Länder, 2019), fruit farms in the Lake Constance region are even smaller with an average of 8.8 ha (Kösler, 2023). The impact of climate change and weather extremes, such as heightened mildew pressure from extended wet periods which results in a greater need for plant protection products and digital tools to combat diseases (Bodensee, 2013), in addition to changing consumer demands and societal criticisms threaten the future of fruit production in the region.

2.2. Stakeholder selection and mapping

Among the numerous identification methods for stakeholder analysis, Freeman's stakeholder definition was selected for this study: "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984). In this study, the "organization" was considered as the fruit production sector and the "objective" was considered as the digitalization of the sector as a potential future scenario. Two key criteria guided the stakeholder selection, which followed a purposive sampling approach (Bryman, 2012): (1) stakeholders identified were either intended users or developers of digital technologies; (2) stakeholders were engaged in the fruit value chain, ranging from the farm- and retail-level to those who viewed the fruit production industry from a wider technology or research lens. As a result of an extensive internet search, which included websites of research projects and groups, farmer associations, and technology development companies, authors compiled a preliminary list of regional stakeholders who met these criteria. An interview was conducted with a German expert in digital farming technologies to improve the draft interview guideline and to find not yet identified stakeholders. Additionally, the authors requested the contact details of farmers who could be interested in participating from a regional advisor on fruit cultivation and a leader of an agricultural group. This iterative process was similar to snowball sampling (Goodman, 1961). The stakeholders were inductively categorized into groups based on their occupation and shared stakes or interests: farmers, cultivation consultants, marketing and wholesale representatives, researchers, technology developers, and representatives of nature, agricultural, and consumer associations.

Authors of the study aimed to conduct five to six interviews for each stakeholder group (Table 1), with the exception of fruit farmers: as they are the intended users of digital technologies in fruit production, have potentially more heterogeneous views, and are most affected by the consumer's perspective, thus have the highest stakes, authors aimed for eight farmer interviews.

Technology developers and nature, agricultural, and consumer associations were limited in the region and were challenging to engage. To better understand how to prioritize activities for engaging stakeholders, the authors used the power-interest matrix developed by Johnson et al. (2008) and adapted from Mendelow (1981) to evaluate the interest and power of stakeholder groups in relation to the influence of digitalization on the public opinion of fruit production (Figure 1). This stakeholder mapping approach identifies stakeholder expectations and power to better understand political priorities, as well as to suggest levels of intervention in the case of engagement challenges (Johnson et al., 2008). Groups with low levels of power and/

Table 1. Result of the analysis of stakeholder groups in fruit production and their descriptions, adapted from Gaber et al. (2024).

Stakeholder group	#	Description
Fruit farmers	8	Farmers predominantly engaged in fruit production on their agricultural land, employing either integrated production[1] (IP) or organic principles.
Technology developers	5	Individuals working as employees or leaders in agricultural machinery or technology companies, ranging from start-ups to international corporations.
Cultivation consultants	5	Individuals, whether privately or publicly employed, advise farmers on on-farm activities and/or the purchase and application of agricultural inputs, such as Plant Protection Products (PPPs) and fertilizers.
Researchers	4	Local or national-based researchers affiliated with public or private institutions possessing knowledge of fruit cultivation, fruit value chain conditions, and/or agricultural technologies.
Nature, agriculture and consumer associations	6	Individuals who are members, employees, or leaders of public or private organizations dedicated to nature preservation, agriculture, or consumer interests. These individuals play a role in representing the interests of groups or communities related to these sectors.
Fruit wholesalers or traders	5	Individuals serving as employees or leaders within fruit wholesale organizations or companies or individuals in similar roles within farm shops that offer local delivery services.

or interest would not merit extenuating efforts to adjust the methodology to be included, whereas groups with high levels of power and/or interest would. As the authors valued technology developers and nature, agricultural, and consumer associations to both have high interest and high power ("key players") in the study, proactive efforts were required to involve these groups. While the authors previously considered the proximity to the Lake Constance region as a priority in the selection of possible interview partners, the authors re-evaluated its importance for these particular groups, considering the national and international scales at which digital technologies are developed. Ultimately, the authors expanded the geographical focus of the stakeholder selection methodology to meet the goal interview number for these groups.[1]

2.3. Stakeholder interviews

In total, 33 stakeholders across the six stakeholder groups participated in 1-hour interviews, which were conducted in German and offered both in-person and online. The interviews were semi-structured with questions based on the research goals. As previously mentioned, an interview guideline (included in the Annex) was developed and improved based on the recommendations provided in the expert interview. The guideline encompasses

[1]The two production systems used in German horticulture are integrated production (IP) and organic. The two systems are distinguished from one another by the use of PPP and the level of holistic integration in the production system (Augustenberg, 2023; Das Grüne Lexikon Hortipendium, 2021). Of the interviewed farmers, three farmed following IP standards, and five following organic standards.

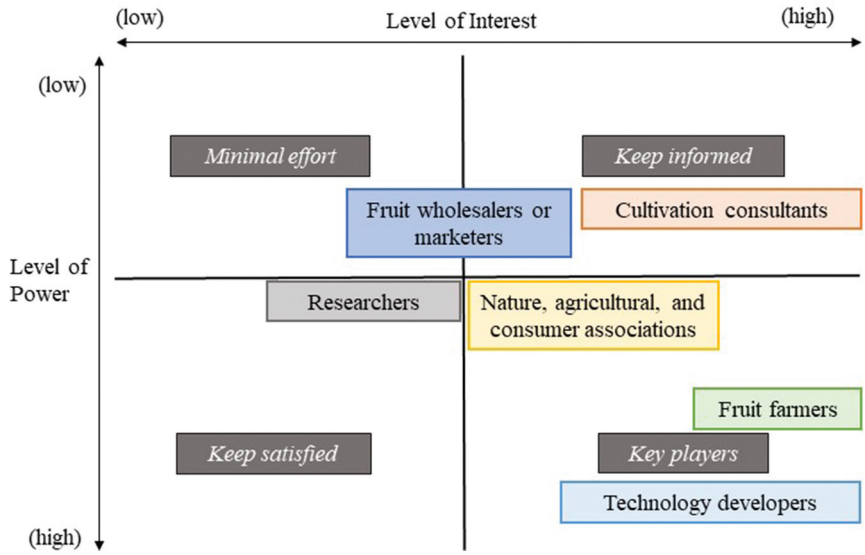

Figure 1. The power-interest matrix of the identified stakeholders regarding digitalization in fruit production based on Johnson et al. (2008) and adapted from Mendelow (1981).

more subjects than are pertinent to the current study because it was used for an interview series as part of the DESIRA project (DESIRA, 2019). The most relevant interview questions for this investigation were 26 and 26(a). Specifically, stakeholders were asked the following questions: (1) in your opinion, would the use of digitalized technologies in fruit production change public opinion about the products or production methods? (Yes, no and what reasons play a role here). (2) Does your answer differ when we speak about the use of digitalized technologies in organic fruit production? (If yes, how and what are the reasons for these differences).

The interviewed stakeholders were predominantly males between 41 and 60 years and most of them lived in mostly rural or mixed regions (Figure 2). All of them had post-secondary training or education. The self-evaluation of knowledge on digitalization in fruit production showed a wide range, with most responses falling in the rather low (39%), medium (30%), and rather high (18%) knowledge categories.

2.4. Interview analysis

The interviews were transcribed and analysed using qualitative content analysis (Mayring, 2000) supported through MaxQDA 2020 software. Authors employed a two-part inductive coding process as outlined by Saldaña (2013). Structural coding was conducted as the first cycle to

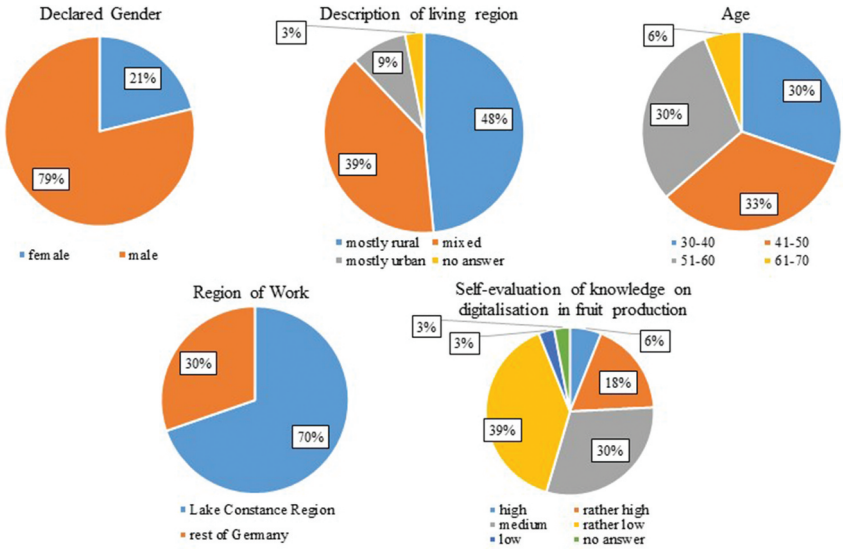

Figure 2. Characteristics of interviewed stakeholders (*n*=33).

break the information into clear sections from within which the authors could further code. For example, for the question "In your opinion, would the use of digitalized technologies in fruit production change public opinion about the products or production methods?", stakeholders responded with either "yes", "no", "I don't know", or "it depends", and thus these four responses became the initial four structural codes. The second cycle of coding involved pattern coding. This coding type was the most suitable for the aims of this study and the open structure of the interview responses as it enabled the description of similarly coded responses through an emerged pattern: in other words, codes were grouped and regrouped as an iterative process to identify emerging patterns in the content per question (Figure 3). First, excerpts within each structural code were descriptively coded. For instance, within the "yes"-coded responses, the responses were given descriptive titles to best describe the excerpt, such as "reduction of PPP". Through this descriptive coding, patterns began to emerge within the "yes" codes; thus, the sub-codes were subsequently grouped into overarching codes to describe these patterns. To continue with the example of the "reduction of PPP" coded excerpt, this stakeholder was describing impact through on-farm usage. Thus, the overarching code "impact through on-farm usage" was used to group this and similar responses. The other identified pattern within the "yes" codes was "impact through increased transparency". All "yes" codes belonged to one of these two patterns. Then, within both of the overarching

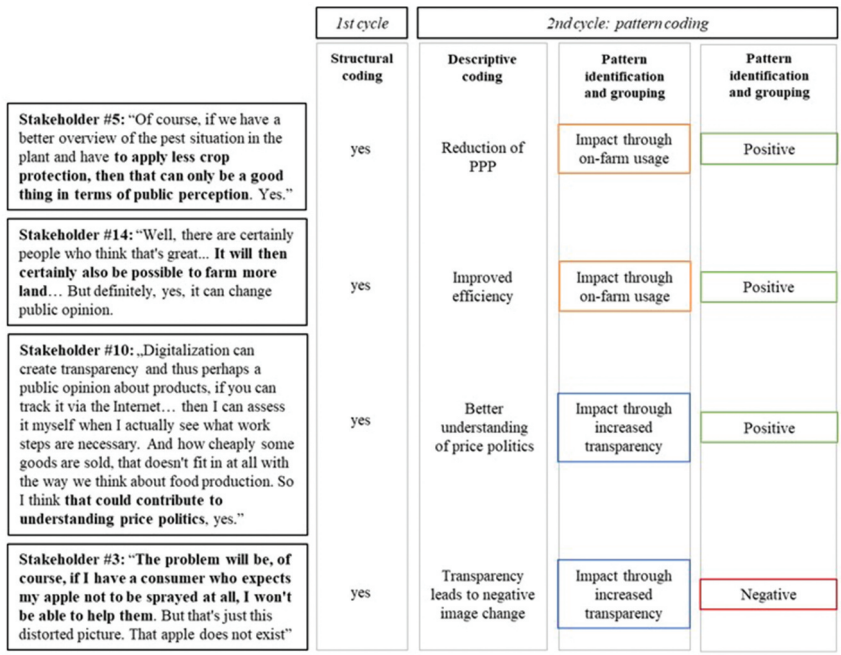

Figure 3. Example of interview coding process using pattern coding (Saldaña, 2013).

codes, a final pattern was identified, namely if the described impact was positive or negative. These patterns are elaborated upon further in the results.

Frequencies of codes per stakeholder group were calculated in an Excel spreadsheet and incorporated into the results as descriptive statistics. However, due to the small sample size and because many stakeholders provided multiple responses (e.g. "yes" and "no") for the questions, the descriptive statistics provided are a minor portion of the results, intended to compliment the more extensive qualitative analysis.

3. Results

Results of the interview responses are provided in the following paragraphs and are structured in the order of the research questions: first, the stakeholder perceptions of public opinion of fruit farming are examined. Second, stakeholder views on how the use of digitalized technologies in fruit farming can influence public opinion are addressed and the emerged themes are explored. The elaborations of the responses are qualitatively reported to explore viewpoints, explanations, and arguments from stakeholders.

3.1. Stakeholder perceptions of public opinion of fruit farming

Based on the responses to the semi-structured interview questions, authors could interpret the stakeholder perceptions of the public opinion of fruit farming. Stakeholders from all groups, regardless of their categorical response to the interview questions, expressed frustration with the public and their current lack of understanding of fruit production methods and agricultural production as a whole. A fruit wholesaler (Stakeholder [S]13) credited agriculture as a sector for this perceived inadequacy, rather than society: "*when we talk about public opinion, I think we have to say that agriculture as a whole has forgotten to take society with it in its development*". Other stakeholders described false information in the media to perpetuate inaccurate ideologies of agricultural production methods. An organic farmer (S20) reported: "*The public has no idea about agriculture anymore . . . there is no knowledge and what is being spread are the personal perceptions of individuals. You can also simply say that they are teachers. And we need to get the knowledge about agriculture, how it works or how it is done, what opportunities and difficulties there are, into the population*". Stigmas against agricultural production methods, which were reported to cause misunderstandings and low acceptance of agricultural production methods, lack of willingness to pay, and misguided pressure on politics were described to originate from narratives provided by the media. A damaging discourse surrounding the use of pesticides has been created at the sake of farmers, despite their invaluable role in feeding the population, described a consultant (S6): "*It is conveyed to society in such a way that the fruit grower gets the feeling that he has only sprayed poison. And that's his hobby, spraying poison and driving a tractor and polluting the environment. I don't know a single farmer who sprays without having to do it. Because it's unpleasant for everyone and it also costs money. But this social service, which actually benefits the world's population, has no social recognition here in our affluent state or in Central Europe*". A researcher (S3) credited marketing by retail chains to project an unattainable image that high-quality products can be made at a low-cost for the end consumer, and this is causing dangerous inaccuracies: "*nothing has diverged as much as the production methods in agriculture and fruit growing and the way they are marketed. That's why the consumer has been continuously misled*".

3.2. General stakeholder views on how digital technologies in fruit farming can impact public opinion

Across all stakeholder groups, 73% believed that digitalization could change the public opinion of general fruit production, regardless of the production system (Figure 4). All consultants and nearly all fruit farmers and representatives from nature, agriculture, and consumer associations reported this. Two

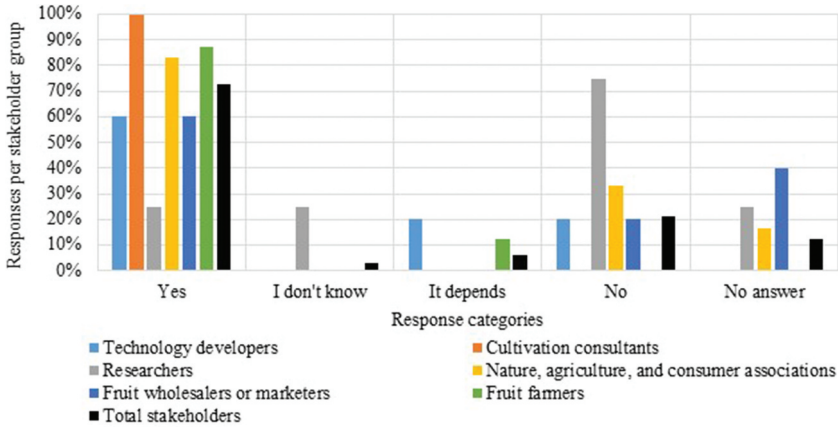

Figure 4. Stakeholder views on if the use of digitalized technologies in fruit production would change public opinion about the products or production methods. Multiple answers were possible.

stakeholders were undecided and responded "it depends": "*not on the use of digitalized technologies, but rather how the collected data are used*" (fruit farmer, S28); "*the answer depends, because just using it won't change anything if it's not known to the public. That means there has to be some kind of marketing*" (technology developer, S33). Of the stakeholders who responded "no" (21% total), most were researchers. Five stakeholders (two researchers, two representatives from nature, agriculture, and consumer associations, and one wholesaler) responded with multiple answers; all but one responded first with "no", then followed up with "yes" during their elaborations. Unless otherwise specified, both responses were considered to have equal value and therefore are included in the results of this study.

Stakeholders were asked if their answer would differ when speaking about the use of digitalized technologies in organic fruit production. This phrasing of this question enabled an open discussion around production system differences. This question can also be interpreted as whether the production system makes a difference in the impact digitalization could have on public opinion of fruit farming. Nearly half (48%) of all stakeholders believed the production system plays a role in the impact digitalization could have on public opinion (Figure 5). For instance, a developer responded, "*I can only imagine that it will have an even stronger effect on the organic ones, because the higher price simply requires greater credibility . . . I think it is perhaps even more valuable for organic farms to demonstrate this traceability and this modernity, and also this progress in principle, if they communicate it accordingly. Of course, it's also an exciting question, because this digitalization doesn't fit in with the dream of many people that farming has to be idyllic and small and*

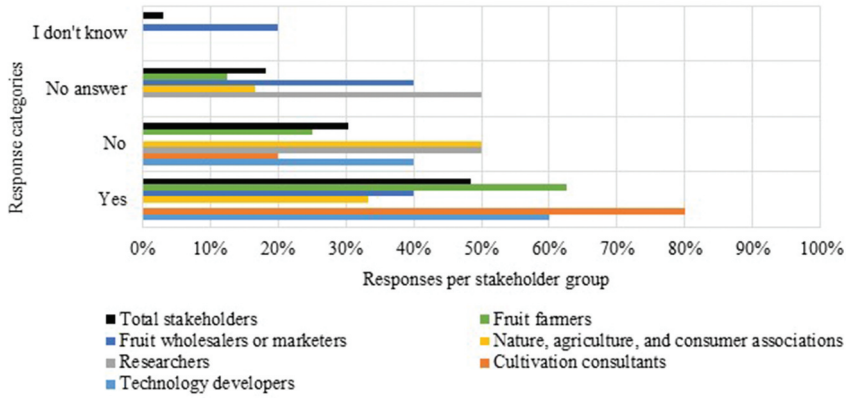

Figure 5. Stakeholder views on whether production system plays a role in how digitalization could impact public opinion of fruit farming. Multiple answers were possible.

with ten different animals on the farm, but yes". (S33). Meanwhile, 30% of stakeholders did not believe this, such as an organic farmer, who mentioned, "*I don't think so, because practically the population or public opinion doesn't even know what technologies are being used . . . No, there is no difference. So, organic and IP will not differ*", (S14). A greater number of stakeholders chose not to respond to this question than for the previous interview question, without justification. Researchers, for instance, either did not provide an answer or did not believe that the production system makes a difference in how digitalization could impact public opinion. The reasons provided by stakeholders will be explored in the following section.

3.3. Digitalization can impact public opinion: Emerged themes

Within the responses from stakeholders who answered "yes" to the interview questions, "In your opinion, would the use of digitalized technologies in fruit production change public opinion about the products or production methods" and "Does your answer differ when we speak about the use of digitalized technologies in organic fruit production?", both positive and negative impacts were anticipated. Overall, positive impacts were described more often than negative. Cultivation consultants and fruit farmers were particularly optimistic in this regard, whereas representatives from nature, agriculture, and consumer associations believed negative impacts could occur more than any other group. However, the key stakeholder group, fruit farmers, expected negative impacts to occur with regard to digitalization in organic fruit production more than any other group. As previously mentioned, interviewed researchers either did not provide an answer to the question

regarding differences between production systems, or they did not believe the production system played a role.

Two sub-categories for how this change could occur became apparent: (1) through increased transparency from the use of digital tools, and (2) direct on-farm impacts from the use of digital tools (Figure 6). For instance, some stakeholders saw positive potential in the increased transparency from farm to fork through digital technologies, while others perceived possible risks that could occur when consumers have the opportunity to see into every day farming activities for the products they consume. Similarly, while the direct impacts from on-farm usage of tools (e.g. automated tractors or drones), such as reduced application of inputs, was seen as promising, adverse effects were also described, including farming practices being perceived as becoming more removed from nature. The reasons behind the categories and sub-categories are listed in Table 2 and will be detailed in the following sections.

3.3.1. Positive impact on public opinion

3.3.1.1. Digital tools for increased transparency. Increased transparency through digital tool use was the most anticipated impact on public opinion among stakeholders (see Figure 6). Stakeholders reported improved trust of farmers and/or farming practices, better understanding of price politics, and

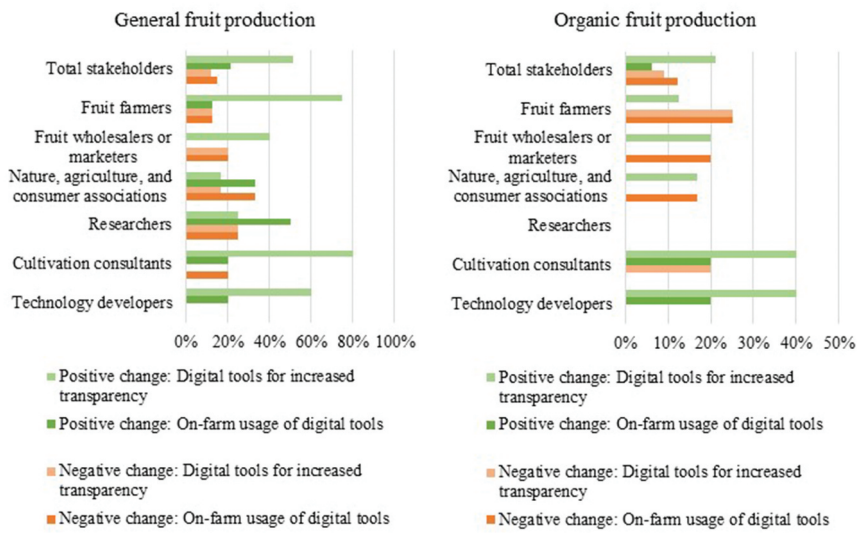

Figure 6. Themes of perceived impacts (positive and negative, through increased transparency or on-farm usage of digital tools) that digitalized technology use in general (regardless of production system) and organic fruit production could have on public opinion, per stakeholder group. Multiple answers were possible.

Table 2. Reasons provided by stakeholders for how digitalized technology use in fruit production could impact public opinion, including specific effects for organic production. The number of stakeholders who mentioned this reason during the interviews is provided. Multiple reasons could be given.

	Positive impact	#	Negative impact	#
	Digital tools for increased transparency			
	improved public understanding of farming practices	7	change of existing perception	5
	improved trust of farmers/farming practices	7		
	better understanding of price politics	2		
	unification of quality standards	1		
	greater understanding of IP production practices	3		
specific effects for organic production:	greater understanding of organic production practices	1	transparency communicates reality of organic methods	3
	more marketing chances for niche bio products	1		
	higher credibility for organic prices	1		
	organic consumers are easier to positively influence through transparency than non-organic consumers	1		
	On-farm usage of digital tools			
	reduction of inputs	3	trust human worker more than automated tool	1
	improved quality, price reduction	1	technologies concern citizens	1
	increased efficiency	1	more technology means more removed from nature	2
	improvement through environmental practices	4	labour reduction	1
	digitalization may reduce differences between production methods	2		
specific effects for organic production:			does not fit to 'natural' organic image	4

unification of quality standards when describing the potential positive impacts on public opinion through increased transparency. For instance, digitalization was described to offer a chance for the public to learn about fruit production".*I think that's an important thing for public opinion, that people can understand everything in detail and know that this is coming from the farmer*", described a developer (S30). Another developer mentioned that just using digitalized technologies, i.e. on-farm digital technology use, would not change public opinion on its own. Rather, the technologies should be used to "open the doors" of the farms to the public and communicate the reality of their production methods: "*Digitalization in the sense that we're talking about in the production chain doesn't help. Unless digitalization also describes communication with the outside world. Then yes. . . digitalization can have a positive influence on public opinion if digitalization is used for this purpose*" (S32). Specifically for organic fruit production, potential change was anticipated more often through improved transparency of the

production method as a function of digital technologies, as this could help to justify the higher price of organic products in the eyes of the consumer. A consultant (S5) explained"*„As far as organic farming is concerned, I would say that if we can now, for example, as I have just described, transparently show how the organic farming system and plant protection work using a field index and corresponding evaluation software, then we will encounter very broad public approval*". Still, improved transparency was not exclusively perceived to favour organic production. A representative from a nature association (S7) described transparency as a motivation for conventional or IP farms to communicate the reality of their methods to the public, in order to achieve greater understanding of their cultivation practices: "*[farming] simply becomes more transparent, you can compare better, you can adhere to standards better, you can present standards and you can also say that these standards are being adhered to accordingly. Yes, digitalization is standardizing everything, so I think that conventional fruit production could score points in public opinion*."

3.3.1.2. On-farm usage of digital tools. Some stakeholders expressed optimism that the on-farm use of digital tools could positively influence public opinion of fruit cultivation products or production systems, particularly regarding the potential to improve environmental standards in production, such as precision application methods that could allow for reduction of agricultural inputs and increased on-farm efficiency. "*From my point of view, it's all about environmental quality. And if [digitalization] results in improvements, then public opinion will also improve*", reported a representative from a nature organisation (S4). Researchers reported potential positive impacts through on-farm usage of digital tools more than any other stakeholder group, while fruit wholesalers or marketers did not anticipate any positive changes related to on-farm usage. A developer described increased efficiency through on-farm technologies to improve the quality of products over time while also reducing the costs of production and therefore price for the consumer (S31). Positive on-farm impacts on public opinion were also reported for organic fruit production, though only by stakeholders within the cultivation consultant and technology developer groups. Stakeholders expected the use of digitalized technologies to decrease the higher production costs of organic fruit farming, which they credited to the higher manual labour and lower yields compared to conventional or IP fruit farming, ultimately reducing the price- and acceptance- gap between conventional and organic products.

3.3.2. Negative impact on public opinion

3.3.2.1. Digital tools for increased transparency. While transparency enabled through digital technologies can offer a positive change through

knowledge sharing, trust, and improved communication, the publication of farm-level information could also negatively influence the opinions of consumers. According to an IP farmer, "*Farms are becoming more and more transparent. This means that the quantities of pesticides and the application and so on are all becoming public. And that can go in one direction or the other under certain circumstances. So I see it in two ways*." (S24). Transparency could de-romanticize production methods for consumers. Stakeholders particularly described this risk for organic production, as consumers with disillusioned concepts of the production method might react negatively to the reality gained through increased transparency. A researcher reported, "*The problem will be, of course, if I have a consumer who expects my apple not to be sprayed at all, I won't be able to help them. But that's just this distorted picture. That apple does not exist*." (S3).

3.3.2.2. On-farm usage of digital tools. Negative impacts were anticipated through direct on-farm use of digital technologies. Mistrust of technologies, particularly flying or autonomous driving technologies like smart tractors or drones, was a common theme: "*And drones are not only a blessing, but also a bit of a curse in the eyes of some people. Yes, because it's simply uncomfortable. Not just because of the noise, but simply because you feel like you're being watched, you don't know what they're filming for*", reported a representative from an agricultural association (S19). The possibility of human labour reduction or replacement through the implementation of on-farm digital tools additionally concerned stakeholders, and was described to risk a negative impact on public image and societal acceptance of farming practices. More stakeholders reported organic fruit farming to be at risk for a negative impact through on-farm use of digital technologies than through increased transparency through digitalization. The presence of digital technologies in organic fruit farming was perceived to contradict the current public opinion: "*In terms of perception, of course, it's somehow bad when you say: 'Yes, the organic farmer, he's flying over there with the drone. Is that even organic? And does he have a computer-controlled harvesting machine? I thought they were using a ladder to get the fruit down from the high trunks' and things like that . . . they say that organic farming is actually like it was 100 years ago. At least that's how people imagine it. And digitalization doesn't fit in there*" explained a fruit wholesaler and marketer (S17).

3.4. Digitalization (alone) cannot impact public opinion: emerged themes

In comparison to the responses by stakeholders who believed digitalization can impact public opinion of fruit production, stakeholders who did not believe this provided limited explanations. Three themes emerged from

these responses: (1) the use of digital technologies are "unseen" by the public; (2) society does not know/care how fruit is produced; and (3) information gained through digitalization is not interesting for the public. Stakeholders who answered "no" were often discouraged by the lack of digital knowledge among consumers, which limits the public's ability to learn about fruit production through increased transparency as a function of digitalization. Still, the majority of "no" responses centred on a perceived lack of societal understanding or interest in agricultural methods. Some stakeholders believed society is already too distanced from food production and digitalization cannot bridge this gap. A researcher (S11) mentioned that digitalization would not impact public opinion on fruit production, "*because the population or public opinion doesn't even know what [current] technologies are being used*". Another researcher (S3) expanded on this point by describing the digital literacy in the general public to be too low for any sort of impact: "*the consumer we're talking about now doesn't have any digital skills either. We are already talking about the fact that consumers are far too far removed from agricultural production processes and that food marketing is characterized by selling a myth of a manufactured world . . . Consumers are not interested in [digitalization] at all because they actually tend to say that even more technology, even more distance from the land, is not good . . . The consumer is educated to believe that modern technology is actually disruptive and feeds the agribusiness lobby, so to speak, at the expense of the consumer and lots of chemicals*." Researcher (S3) described this "myth of food production" to be a lie: "*As long as people believe that, I as a producer have actually lost completely. All these tools won't help me, I first need to build up a new image of production, new confidence in myself as a person in my business. These documentation tools can help me a little with that*". An organic farmer argued that, first and foremost, the foundational knowledge in society around agricultural production methods is in need of improvement: "*what we can do with digitalization, with digital technologies, is that we can document that we are doing everything in accordance with the law. But if people don't understand the meaning and purpose behind it, it's no better because of that*", reported an organic farmer (S20). While digital tools like social media can help to give a realistic picture to the fruit, this is only feasible if the farmers have the capacity to use the tools. Researcher S3 described this as an unrealistic task to add on top of the extensive daily workload of a farmer.

Impact on public opinion of fruit farming may not be contingent upon the use of digital technologies in fruit farming, but rather the narrative surrounding their use and impacts. "*On the producers' side, the only chance now is not to talk about digitalization or technology, but to talk about what they really do*." reported researcher S3. This researcher recommends that producers use digitalization to communicate to the public that they (1) understand the concerns of the public and (2) are taking all possible measures to reach

their demands. Stakeholders suggested that a positive change on the public image of fruit production could occur if the communication about digitalization were to focus on environmental aspects. "*I can imagine that if the press were to report that the use of pesticides can be reduced with new technologies, then I think it would certainly have a positive impact on public opinion*," reported a researcher (S11). Still, the discourse on digitalized fruit production must remain neutral and informative to improve societal knowledge and build trust between producers and consumers. "*If the customer has the feeling that digitalization helps to grow the product in an even more environmentally friendly, climate-friendly and healthy way, then they are in favour of it. But if they just think: 'It's just a technology that observes us even more, controls us more. It calls certain things into question in terms of data protection', then there is simply a lack of transparency as far as the consumer is concerned*", described a representative from an agricultural organization (S19).

4. Discussion

4.1. Methodological considerations

Several methodological aspects limited this study. To begin, the average farm size in the region is significantly smaller than the national average, which may influence how digitalization was perceived. This region is known for its small- to medium- sized family farms, which have been found to lack digitalization (Regan et al., 2018) and to adopt digital technologies less frequently than larger farms due to structural challenges (Kernecker et al., 2020; Linsner et al., 2021). German family-run farms tend to favour well-established solutions over innovations (Cravotta & Grottke, 2019). The self-evaluation of knowledge on digitalization in fruit production ranged greatly, with most responses falling in the rather low (39%), medium (30%), and rather high (18%) knowledge categories. This was to be expected, as only some of the stakeholders work directly with digitalization, and others were selected based on their knowledge of the regional fruit value chain. Additionally, stakeholders were not provided with a definition or examples of digitalization in fruit production; therefore, their responses are dependent upon their personal interpretation of digitalization in fruit production. Considering that the adoption of digital technologies in the fruit sector is lagging behind other agricultural sectors (Ossevoort et al., 2016), variations in experience with the topic among stakeholders are to be expected. Digitalization in agriculture has been notoriously challenging to define, as numerous terms have emerged to explain the different forms of digitalized agricultural systems (Klerkx et al., 2019). While the variations in interpretations provided valuable insights for this study, they also suggest a need to disambiguate the term "digitalization" for all potential users within this sector. Finally, while the frequent criticisms expressed by

stakeholders over societal knowledge on agricultural practices could have hinted towards a stakeholder bias, the authors of this study see value in these results as they are as follows: despite an overall negative outlook on the current state of public opinion, stakeholders still see the value that functions of digitalization can offer.

4.2. The digitalization narrative

Stakeholders in this study largely conveyed optimism that digitalization could create a positive change in the public perception of fruit production and lead to a variety of trickle-down impacts, such as improved price politics. On the other side, stakeholders who expressed frustration with society's current knowledge on agricultural production frequently credited media for this perceived lack and noted that digitalization's impact on public opinion of fruit production may be contingent upon the media's chosen narrative surrounding it. In this way, the narrative around the employment and effects of digital technologies in fruit farming may have a greater influence on public opinion of the industry than their actual use. Indeed, media reports hold immense power in how the public think about issues (McCombs & Valenzuela, 2021). Yet the supply of information is rarely neutral, as media have incentives to provide eye-catching, often controversial narratives around current topics (McCluskey & Swinnen, 2004). A study by Yuksel et al. (2017) found that society pays more attention to negative reporting, which is referred to as the bad-news hypothesis. Still, research shows that German media tend to support new technologies (e.g. Metag & Marcinkowski, 2014). A study by Mohr and Höhler (2023) conducted a content analysis of German media content published from 2016 to 2019 on digitalization in agriculture and found that the majority of analysed arguments were positive (59%), while almost 24% were negative and around 18% were neutral. Favourable media coverage of this topic was encouraged in the study by Mohr and Höhler as an opportunity to improve societal acceptance of digitalized agriculture. The stakeholders in this study expand this opportunity to include societal acceptance of agriculture methods in fruit production.

Furthermore, while technical details of agricultural processes are unlikely to interest the public (Pfeiffer et al., 2021), the potential for digitalization to improve environmental or social conditions, such as those anticipated by stakeholders in this study, can be used as an argument to support the use of digital technologies. Literature indicates that communication of the positive effects of digital technology use is a critical part of the narrative as digitalization progresses; without this narrative, studies initially yielded neutral or negative results on the impact on public perception. The representative study conducted by Wilmes et al. (2022) first indicated that German citizens perceive a negative affect of digital

technologies on willingness to buy food products from large and conventional farms. However, when environmental arguments for the use of the technologies were introduced to the participants, a positive influence on the willingness to buy food products from those farming systems was observed. Furthermore, the outcomes of the study by Treiblmaier and Garaus (2023) highlighted that the benefits of blockchain technology use in the food supply chain could only be realized by informing the public of these benefits, such as through blockchain labels, which were found to have a positive effect on purchase intention through perceived product quality.

5. Implications and conclusions

5.1. Change through on-farm use of digital tools

Stakeholder responses to the interview questions demonstrated two categories of potential change–positive or negative–and two sub-categories for how this change could occur–through increased transparency or through the on-farm use of digital tools. Other functions of digitalized technologies that enable improved transparency, such as communication between farmers and other value-chain actors for knowledge exchange or improved management of farms through digitalized management systems, were not mentioned. While it can be assumed that the interviewed stakeholders did not value these missing functions to have a potential impact on public image, it is also possible that these tools were not known by stakeholders to belong to digitalized fruit production. The digital tools and their functions described to have potential positive impacts on public image, such as improved efficiency and reduction of PPP, were localized to on-farm activities and fit most closely to the concept of precision farming (Eastwood et al., 2019). This could imply that the stakeholders who responded optimistically regarding on-farm usage of digital technologies might be lacking information on the concept of digitalization in agriculture. While precision farming is a component of the broader concept of digital agriculture, it does not consider the transfer, collection, and/or analysis of data to improve on- and off-farm activities and decision-making (Leonard et al., 2017) as a farm system technologization (DLG e.V. & Griepentrog, 2019), which is the typical understanding of digital agriculture (Ingram & Maye, 2020). Interestingly, most of the described negative impacts through on-farm usage of digital technologies, including mistrust of automated technologies and possible redundancy of human labourers, fit better to the concept of digital agriculture. These results suggest that it may not be the digitalization of fruit production as a whole that stakeholders perceive to impact public image, but rather specific aspects of

digitalization, such as automation. Future research initiatives should continue to explore these aspects, the outcomes of which are valuable for understanding how public opinion on agriculture could be impacted by the use of digital tools in food production.

5.2. Change through increased transparency

Stakeholders in this study emphasized the risk that data transparency to consumers could create a negative impact on public opinion of fruit farming, depending on the consumers' prior knowledge and expectations. Increased transparency through digital technologies goes hand-in-hand with the topic of on-farm data use and governance. Some studies have found that digitalization of farming practices adds a new vulnerability for farmers regarding data ownership. Misuse of on-farm data may lead to reputation damage of the participating farmers. A number of studies reveal risks perceived by stakeholders in the agricultural sector to surround the ownership and sharing of on-farm data (e.g. Jakku et al., 2019; Lioutas et al., 2019; Regan, 2019; Wiseman et al., 2019). Improving the foundational knowledge of society around agricultural production methods, which could mitigate the risk of negatively influencing opinions of the public with incorrect conceptions of farming, was encouraged as a critical first step towards improved public acceptance. However, studies have found that access to more comprehensive information on a topic does not always lead to greater acceptance (Scholderer & Frewer, 2003; Weary & Von Keyserlingk, 2017; Wuepper et al., 2019). Opinions on agricultural practices are deeply rooted and are based on personal experience, knowledge, values, and beliefs (Te Velde et al., 2002). Because of this, simply providing more information on a topic is not likely to significantly improve public opinion (Grunert et al., 2003). Therefore, increasing foundational knowledge of agriculture through digitalization should not be the main priority of digitalization. Instead, direct engagement with the public could be more successful with mitigating public concerns than education strategies. This strategy has been successful in other agricultural sectors, such as animal husbandry (Weary & Von Keyserlingk, 2017). Digital technologies that would enable two-way communication between the public and farmer, such as digital platforms and apps that facilitate direct marketing and social innovations like community-supported agriculture (CSA), would support the expressed interests of the stakeholders. Nevertheless, the perceived deficit in digital literacy among both the farmers and the public suggest a necessary first-step of capacity building. This could include digital training for farmers through, for instance, the tool development companies, and the use of simplified, non-technical language in the public discourse, including media, around digitalized fruit cultivation. Additionally, the use of these tools

must not significantly increase the already heavy workload of farmers, but rather ease the tensions between farmers and the public.

When asked about the role of digitalization and fruit production's public image, stakeholders prioritized finding ways of fair communication, which on the one hand show a bit of honesty towards the consumer but also improve the image of the farmer. Public acceptance of digitalization has been found to not only be determined by the characteristics and impacts of the digital technologies but also on the trust of the farmers, who are given the responsibility to use digitalization in the best way possible (Pfeiffer et al., 2021). The main drivers of public acceptance of farming systems are citizens trust in those systems (Birkle et al., 2022); thus, building trust through the use of digitalized technologies would take a critical step towards improved societal acceptance of agriculture.

5.3. Digital transformation as an ongoing process

Considering the challenges posed by societal criticisms of modern agricultural practices and the persistent, rapid development of digital technologies for the sector, actors should seize the perceived opportunity to improve the public acceptance of fruit cultivation. At the same time, the possible risk of worsening public acceptance cannot be ignored, nor should the described contingency regarding the narrative around digitalization and the concerns over low foundational knowledge on agriculture. Lessons learned from previous rapid technological advancements in agriculture should be considered; for instance, one-sided technology driven approaches to the development and use of agri-biotechnology previously led to negative public acceptance issues (Krüger et al., 2018). This lesson is particularly critical to consider, given that there is evidence of a similar one-sided technology-push (versus market-pull) in the digital transformation of the German fruit cultivation sector (Gaber et al., 2024). On the other side, existing research also indicates how other sectors could counteract their previously low public acceptance through similar opportunities to those highlighted in this article. Trust and perceived benefits to modern practices have been found by Birkle et al. (2022) to be drivers towards acceptance of animal husbandry systems from German citizens. Similarly, knowledge, transparency, and communication between sectoral stakeholders and the public were found to increase trust in novel bio-economic products (Krüger et al., 2018).

In contrast to the rapid progression of digitalization, understanding the impact that it may have on public opinion of agriculture must take a slower approach. Values, such as public opinion and acceptance, are maintained within individuals, but are deeply embedded in the social-ecological context and evolve over time (Manfredo et al., 2017). Change, especially value shift in response to social-ecological change, is likely to be slow and over long

periods of time (Kendal & Raymond, 2019; Manfredo et al., 2017). Particularly in established, traditional agricultural regions, such as in the Lake Constance region, the landscape interface, or the dynamic physical and cultural space resulting from the interaction between social and ecological systems, shapes and is shaped by the local value system (Horcea-Milcu et al., 2018). Changes to the landscape interface, such as the introduction of digital technologies to the fruit cultivation sector, and the resulting changes in actors' values may experience a "value change debt" or time lag (Horcea-Milcu et al., 2018). This value change debt suggests that the lasting impact on public opinion may not be determinable in-situ with the digital transformation of fruit cultivation, but will rather continue to evolve past the initial "boom" of development and implementation.

Understanding how digital technology use influences public opinions is still in its infancy. While many studies exist on the acceptance *of* digital technologies in various sectors and in agriculture, fewer studies exist on how digital technology use may *influence* the public acceptance or perception of the sectors. Although the results of this study provide novel insights into this topic and the first of its kind for the German fruit cultivation sector, the previously mentioned methodological considerations indicate the need for further research. As the digital transformation in fruit cultivation and agriculture as a sector is an ongoing process, it is important to consider that as researchers, we can analyse continuous change, yet impacts should be considered as interim and plenary (Fischer et al., 2021). The recording of these impacts during a transformation can serve for comparison between different phases of the transformation and may indicate which interventions impacted changes within the interim results during the process. Continuous monitoring of the impact of digital technology use on the public opinion of fruit products and production systems would provide a more comprehensive understanding of how these perceptions change over time.

Encouraging a gradual pace of change would be fruitful for understanding the impact that digital technologies may have on the public acceptance of agriculture, including fruit cultivation. Incremental approaches grounded in the findings of this study may best support this gradual change of public opinion of fruit cultivation over time. First, influential actors such as policy makers, industry leaders, and technologists should set realistic expectations for digitalization's ability to shift public perception. The use of non-technical and factual language around digitalization in fruit production in the public discourse at these levels (government, industry, and research) and in the media would support this. This could also function to foster public trust of the information provided and discourage myths surrounding digital technology use in agriculture, which could negatively influence the public opinion. Given their influence, these groups should set the precedent for how the narrative around digital technology use in fruit cultivation and agriculture in general is used. Following the establishment of a consistent, factual narrative to the public and

to the intended users, these actors should aim to provide and support training opportunities for users, such as farmers, on the use of digital tools to improve digital literacy at the farm level. Next, development efforts and support should focus on creating technologies that function to ease tensions between farmers and public, building trust towards farmers and their farming practices. Ongoing research initiatives to monitor the change in public opinion during and beyond this digital transformation, as well as differences in impacts based on specific aspects of digitalization like automation, are encouraged.

6. Conclusion

This study established novel insights on the anticipated impacts of digitalization on the public opinion of fruit cultivation. Digital technology use in fruit cultivation in the Lake Constance region may create both positive and negative impacts through increased transparency and on-farm use of the tools, according to stakeholders in this study. In addition to an honest discourse surrounding the use of digital technologies in fruit production, authors emphasize that enabling personal dialogue between the public and farmers should be a central goal of digitalization to improve the public image of agriculture. Digitalization can be a tool for fair, honest communication directly from farmer to consumer, under the right conditions. Access and use by farmers should be supported through trainings and straightforward, efficient operation. However, to impact public opinion or to work against stigmas around agricultural production, digitalization is not the focus, but rather a means to an end. Ultimately, digitalization cannot be viewed as a silver bullet, as it is sometimes perceived, for current challenges in fruit cultivation like societal acceptance; due to the complex nature of public image and societal acceptance of the agriculture and food sector, any change will be gradual and cannot be impacted by digitalization alone.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the DESIRA Project, funded by the European Commission under Grant Agreement No. 818194.

ORCID

Kirsten Gaber http://orcid.org/0000-0002-6768-9047
Christine Rösch http://orcid.org/0000-0003-3908-1218
Claudia Bieling http://orcid.org/0000-0001-5001-4150

Consent for publication

Informed consent was obtained from all individual participants interviewed for the study.

Abbreviations

CSA	Community Supported Agriculture
PPP	Plant Protection Product
IP	Integrated Production
S	Stakeholder (for interview excerpts)

References

Adarsch, A., Pranav, P. M., & Manjunath, C. R. (2018). Fruit farm surveillance using drones. *International Journal of Trend in Scientific Research and Development*, *2*(4), 351–357. https://doi.org/10.31142/ijtsrd12973

Augustenberg, L. T. (2023). Integrierter Pflanzenschutz, 2023: Erwerbsobstbau.

Baden Württemberg, S. L. (2022a). *Baumobstfläche nach Obstart: Landkreis Bodensee 2017 und 2022*. *Bodennutzung*. https://www.statistik-bw.de/Landwirtschaft/Bodennutzung/0502308x.tab?R=KR435

Baden Württemberg, S. L. (2022b). *Baumobstfläche nach Obstart: Landkreis Konstanz 2017 und 2022*. https://www.statistik-bw.de/Landwirtschaft/Bodennutzung/0502308x.tab?R=KR335

Baden Württemberg, S. L. (2022c). *Baumobstfläche nach Obstart: Landkreis Ravensburg 2017 und 2022*. https://www.statistik-bw.de/Landwirtschaft/Bodennutzung/0502308x.tab?R=KR436

Baeten, J., Donné, K., Boedrij, S., Beckers, W., & Claesen, E. (2008). Autonomous fruit picking machine: A robotic apple harvester BT. In C. Laugier & R. Siegwart (Eds.), *Field and service robotics: Results of the 6th international conference* (pp. 531–539). Springer. https://doi.org/10.1007/978-3-540-75404-6_51

Balmann, A. (2016). *Über Bauernhöfe und Agrarfabriken: Kann die Landwirtschaft gesellschaftliche Erwartungen erfüllen?*. https://ageconsearch.umn.edu/record/251889/

Barbole, D. K., Jadhav, P. M., & Patil, S. B. (2022). A review on fruit detection and segmentation techniques in agricultural field BT. In J.-I.-Z. Chen, J. M. R. S. Tavares, A. M. Iliyasu, & K.-L. Du (Eds.), *Second International conference on image processing and capsule networks* (pp. 269–288). Springer International Publishing.

Bayerisches Landesamt für Statistik. (2018). *Baumobstflächen und -bestände in Bayern*. https://www.statistik.bayern.de/mam/produkte/veroffentlichungen/statistische_berichte/c1800c_201751_16735.pdf

Biegert, K. (2022). *Smart horticulture: Application of sensors and modelling to predict fruit growth, quality and storage behaviour of 'braeburn' apples* [Doctoral dissertation]. Hochschule Geisenheim University.

Birkle, I., Klink-Lehmann, J., & Hartmann, M. (2022). Different and alike: Level and determinants of public acceptance of fattening pig, beef cattle and broiler farming in Germany. *Meat Science*, *193*(March), 108946. https://doi.org/10.1016/j.meatsci.2022.108946

Bitkom, D., & Bauernverband, R. (2020). *Schon 8 von 10 Landwirten setzen auf digitale Technologien*. https://www.bitkom.org/Presse/Presseinformation/Schon-8-von-10-Landwirten-setzen-auf-digitale-Technologien

Bodensee, S. (2013). Zukunftsfähiger Bodensee: Jahresbericht 2013. https://www.bodensee-stiftung.org/wp-content/uploads/BoSti_Jahresbericht_13_0.pdf

Bryman, A. (2012). *Social research methods* (Vol. 4). Oxford University Press.

Bundesministerium für Ernährung und Landwirtschaft. (2016). *Der Gartenbau in Deutschland: Auswertung des Gartenbaumoduls der Agrarstrukturerhebung 2016*. *Der Gartenbau in Deutschland*. https://www.bmel.de/SharedDocs/Downloads/Broschueren/Gartenbauerhebung.pdf?__blob=publicationFile

Bund für Umwelt und Naturschutz Deutschland. (2019). Chancen und Risiken der Digitalisierung in der Landwirtschaft: Diskussionspapier des BAK Landwirtschaft. *Chancen und Risiken der Digitalisierung in der Landwirtschaft*. https://doi.org/10.5771/9783748903604-77

Cerda, A. A., García, L. Y., Ortega-Farías, S., & Ubilla, Á. M. (2012). Consumer preferences and willingness to pay for organic apples. *Ciencia e investigación agraria*, *39*(1), 47–59. https://doi.org/10.4067/s0718-16202012000100004

Chemnitz, C., Wenz, K., & Haffmans, S. (2022). *Pestizidatlas, 2022: Daten und Fakten zu Giften in der Landwirtschaft*. *Heinrich-Böll-Stiftung*. https://www.boell.de/de/2022/01/04/pestizidatlas

Cravotta, S., & Grottke, M. (2019). Digitalization in German family firms - some preliminary insights. *Journal of Evolutionary Studies in Business*, *4*(1), 1–25. https://doi.org/10.1344/jesb2019.1.j051

Das Grüne Lexikon Hortipendium. (2021). *Gemüseanbau: Bio oder Konventionell*. https://hortipendium.de/Gemüseanbau:_Bio_oder_Konventionell

DESIRA. (2019). *The project: About DESIRA*. https://desira2020.eu/the-project/

Deutsche Landwirtschafts-Gesellschaft. (2018). *Digitale Landwirtschaft: Ein Positionspapier der DLG*. *Digitale Landwirtschaft*. https://www.dlg.org/fileadmin/downloads/fachinfos/DLG_Position_Digitalisierung.pdf

Duncan, D. W., & Broyles, T. W. (2006). A comparison of student knowledge and perceptions toward agriculture before and after attending a Govenor's school for agriculture. *NACTA Journal*, *50*(1), 16–21.

Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B. (2019). Managing socio-ethical challenges in the development of smart farming: From a fragmented to a comprehensive approach for responsible research and innovation. *Journal of Agricultural & Environmental Ethics*, *32*(5–6), 741–768. https://doi.org/10.1007/s10806-017-9704-5

Fischer, C., Heuberger, M., & Heine, M. (2021). Schwerpunkt the impact of digitalization in the public sector. 1–21.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman Publishing.

Fu, S., Ma, R., He, G., Chen, Z., & Liu, H. (2023). A study on the influence of product environmental information transparency on online consumers' purchasing behavior of green agricultural products. *Frontiers in Psychology*, *14*(April), 1–11. https://doi.org/10.3389/fpsyg.2023.1168214

Gaber, K., Rösch, C., & Bieling, C. (2024). Digital transformation of fruit farming in Germany: Digital tool development, stakeholder perceptions, adoption, and barriers. *NJAS: Impact in Agricultural and Life Sciences*, *96*(1). https://doi.org/10.1080/27685241.2024.2349544

Genuss Bayern. (2024). *Obst vom Bodensee*. https://www.spezialitaetenland-bayern.de/spezialitaeten/obst-vom-bodensee/

Goodman, L. A. (1961). Snowball sampling. *Annals of Mathematical Statistics*, *32*(1), 148–170. https://doi.org/10.1214/aoms/1177705148

DLG e.V., & Griepentrog, H. W. (2019). *Digitalisierung in der Landwirtschaft (DLG-Merkblatt, 447)*. http://www.bauernverband.de/36-digitalisierung-in-der-landwirtschaft%0Ahttps://www.bitkom.org/noindex/Publikationen/2016/Positionspapiere/Digitalisierung-in-der-Landwirtschaft/Bitkom-Positionspapier-Digitalisierung-in-der-Landwirtschaft.pdf

Grimminger, R., Krawutschke, M., & Berger, S. (2018). *Mehr Bio vom Bodensee durch Tradition und Innovation*. Landratsamt Bodenseekreis.

Grunert, K. G., Bredahl, L., & Scholderer, J. (2003). Four questions on European consumers' attitudes toward the use of genetic modification in food production. *Innovative Food Science & Emerging Technologies*, *4*, 435–445. https://doi.org/10.1016/S1466-8564(03)00035-3

Horcea-Milcu, A. I., Abson, D. J., Dorresteijn, I., Loos, J., Hanspach, J., & Fischer, J. (2018). The role of co-evolutionary development and value change debt in navigating transitioning cultural landscapes: The case of Southern Transylvania. *Journal of Environmental Planning and Management*, *61*(5–6), 800–817. https://doi.org/10.1080/09640568.2017.1332985

Igo, C., & Frick, M. (1999). A case study assessment of standard and benchmarks for implementing food and fiber systems literacy. *Proceedings of the 18th Annual Western Region Agricultural Education Research Meeting* (Vol. 18). https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=4b655d71ebd8148a28097292a67183e0571ebd23

Ingram, J., & Maye, D. (2020). What are the implications of digitalisation for agricultural knowledge? *Frontiers in Sustainable Food Systems*, *4*(May), 1–6. https://doi.org/10.3389/fsufs.2020.00066

Jakku, E., Taylor, B., Fleming, A., Mason, C., Fielke, S., Sounness, C., & Thorburn, P. (2019). "If they don't tell us what they do with it, why would we trust them?" trust, transparency and benefit-sharing in smart farming. *NJAS: Wageningen Journal of Life Sciences*, *90-91*, 1–13. https://doi.org/10.1016/j.njas.2018.11.002

Johnson, G., Scholes, K., & Whittington, R. (2008). Strategic purpose. *Exploring corporate strategy* (Vol. 8, pp. 132–172). Pearson Education Limited.

Kassanuk, T., & Phasinam, K. (2022). Design of blockchain based smart agriculture framework to ensure safety and security. In *Materials Today: Proceedings* (Vol. 51, pp. 2313–2316). https://doi.org/10.1016/j.matpr.2021.11.415

Kendal, D., & Raymond, C. M. (2019). Understanding pathways to shifting people's values over time in the context of social-ecological systems. *Sustainability Science*, *14*(5), 1333–1342. https://doi.org/10.1007/s11625-018-0648-0

Kernecker, M., Knierim, A., Wurbs, A., Kraus, T., & Borges, F. (2020). Experience versus expectation: Farmers' perceptions of smart farming technologies for cropping systems across Europe. *Precision Agriculture*, *21*(1), 34–50. https://doi.org/10.1007/s11119-019-09651-z

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS - Wageningen Journal of Life Sciences*, *90*(November), 100315. https://doi.org/10.1016/j.njas.2019.100315

Kodors, S., Lacis, G., Zhukov, V., & Bartulsons, T. (2020). Pear and apple recognition using deep learning and mobile. *Engineering for Rural Development*, *19*(May), 1795–1800. https://doi.org/10.22616/ERDev.2020.19.TF476

Kösler, J. (2023). Statistisches Monatsheft Baden-Württemberg: Der baden-württembergische Baumobstanbau.

Krüger, A., Schäfers, C., Schröder, C., & Antranikian, G. (2018). Towards a sustainable biobased industry - highlighting the impact of extremophiles. *New Biotechnology*, *40*, 144–153. https://doi.org/10.1016/j.nbt.2017.05.002

Kühl, S., Bayer, E., & Schulze, M. (2023). The role of trust, expectation, and deception when buying organic animal products. *Animal Frontiers*, *13*(1), 40–47. https://doi.org/10.1093/af/vfac080

Landwirtschaft, Z. (2021). *The future of agriculture: A common agenda*. https://www.bundesregierung.de/resource/blob/975226/1982458/1f7412d70d982c2307340abb5ba941c0/2021-11-17-landwirtschaft-data.pdf?download=1

Landwirtschaftliche Rentenbank. (2018). Geschäftsbericht 2018. Landwirtschaftliche Rentenbank.

Lang, M., & Rodrigues, A. C. (2022). A comparison of organic-certified versus non-certified natural foods: Perceptions and motives and their influence on purchase behaviors. *Appetite*, *168*(July 2021), 105698. https://doi.org/10.1016/j.appet.2021.105698

Leonard, E., Rainbow, R., Trindall, J., Baker, I., Barry, S., Darragh, L., Darnell, R., George, A., Heath, R., Jakku, E., Laurie, A., Lamb, D., Llewellyn, R., Perrett, E., Sanderson, J., Skinner, A., Stollery, T., Wiseman, L., Wood, G., & Zhang, A. (2017). *Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia*. https://www.crdc.com.au/sites/default/files/CRD18001-001 CRDC

Linsner, S., Kuntke, F., Steinbrink, E., Franken, J., & Reuter, C. (2021). The role of privacy in digitalization - analyzing perspectives of German farmers. *Proceedings on Privacy Enhancing Technologies*, *2021*(3), 334–350. https://doi.org/10.2478/popets-2021-0050

Lioutas, E. D., Charatsari, C., La Rocca, G., & De Rosa, M. (2019). Key questions on the use of big data in farming: An activity theory approach. *NJAS - Wageningen Journal of Life Sciences*, *90-91*, 1–12. https://doi.org/10.1016/j.njas.2019.04.003

Manfredo, M. J., Bruskotter, J. T., Teel, T. L., Fulton, D., Schwartz, S. H., Arlinghaus, R., Oishi, S., Uskul, A. K., Redford, K., Kitayama, S., & Sullivan, L. (2017). Why social values cannot be changed for the sake of conservation. *Conservation Biology*, *31*(4), 772–780. https://doi.org/10.1111/cobi.12855

Marinoudi, V., Lampridi, M., Kateris, D., Pearson, S., Sørensen, C. G., & Bochtis, D. (2021). The future of agricultural jobs in view of robotization. *Sustainability (Switzerland)*, *13*(21), 12109. https://doi.org/10.3390/su132112109

Mayring, P. (2000). Qualitative content analysis. *Forum: Qualitative Social Research*, *1*(2), 10.

McCluskey, J. J., & Swinnen, J. F. M. (2004). Political economy of the media and consumer perceptions of biotechnology. *American Journal of Agricultural Economics*, *86*(5), 1230–1237. https://doi.org/10.1111/j.0002-9092.2004.00670.x

McCombs, M., & Valenzuela, S. (2021). *Setting the agenda: Mass media and public opinion* (3rd ed.). Polity Press. https://books.google.de/books?hl=de&lr=&id=E-UJEAAAQBAJ&oi=fnd&pg=PT3&ots=Sr0lpKiKS9&sig=HXJCC93ADKDLWvJ1xCfpVlBfzaM&redir_esc=y#v=onepage&q&f=false

Mendelow, A. L. (1981). Environmental scanning - the impact of the stakeholder concept. In *Proceedings of the international conference on information systems* (pp. 407–417).

Metag, J., & Marcinkowski, F. (2014). Technophobia towards emerging technologies? A comparative analysis of the media coverage of nanotechnology in Austria, Switzerland and Germany. *Journalism*, *15*(4), 463–481. https://doi.org/10.1177/1464884913491045

Miranda, J. C., Gené-Mola, J., Zude Sasse, M., Tsoulias, N., Escolà, A., Arnó, J., Rosell-Polo, J. R., Sanz-Cortiella, R., Martínez-Casasnovas, J. A., & Gregorio, E. (2023). Fruit sizing using AI: A review of methods and challenges. *Postharvest Biology and Technology*, *206*(September), 112587. https://doi.org/10.1016/j.postharvbio.2023.112587

Mohr, S., & Höhler, J. (2023). Media coverage of digitalization in agriculture - an analysis of media content. *Technological Forecasting & Social Change*, *187*, 122238. https://doi.org/10.1016/j.techfore.2022.122238

Nesheim, M. C., Oria, M., & Yih, P. T. (2015). A framework for assessing effects of the food system. *A Framework for Assessing Effects of the Food System*. https://doi.org/10.17226/18846

Nordmark, L., Skjöldebrand, C., Johansson, C., Segerström, M., Tahir, I., Gilbertsson, M., Ellner, F., Oskarsson, M., Hydbom, O., & Jensen, J. (2021). Launch of IoT and artificial intelligence to increase the competitiveness in Swedish apple and grapevine production. *Acta Horticulturae*, *1314*, 235–240. https://doi.org/10.17660/ActaHortic.2021.1314.30

Ossevoort, R., Verdouw, C., Frans De Jong, P., Hennen En, W., & Robbemond, R. (2016). *Fruit 4.0: De vruchten van meer technologie Technologie-roadmap*. http://library.wur.nl/WebQuery/wurpubs/fulltext/385030

Pfeiffer, J., Gabriel, A., & Gandorfer, M. (2021). Understanding the public attitudinal acceptance of digital farming technologies: A nationwide survey in Germany. *Agriculture and Human Values*, *38*(1), 107–128. https://doi.org/10.1007/s10460-020-10145-2

Regan, Á. (2019). 'Smart farming' in Ireland: A risk perception study with key governance actors. *NJAS: Wageningen Journal of Life Sciences*, *90-91*, 1–10. https://doi.org/10.1016/j.njas.2019.02.003

Regan, Á., Green, S., & Maher, P. (2018). Smart farming in Ireland: Anticipating positive and negative impacts through a qualitative study of risk and benefit perceptions amongst expert actors in the Irish agri-food sector. In *13th European IFSA symposium: Theme 4-smart technologies in farming and food systems, July 2018* (pp. 1–18). http://ifsa.boku.ac.at/cms/fileadmin/Proceeding2018/Theme4_Regan.pdf

Román, S., Sánchez-Siles, L. M., & Siegrist, M. (2017). The importance of food naturalness for consumers: Results of a systematic review. *Trends in Food Science & Technology*, *67*, 44–57. https://doi.org/10.1016/j.tifs.2017.06.010

Rumble, J. N., & Irani, T. (2016). Opening the doors to agriculture: The effect of transparent communication on attitude. *Journal of Applied Communications*, *100*(2). https://doi.org/10.4148/1051-0834.1030

Saldaña, J. (2013). *The coding manual for qualitative researchers*. Sage.

Scholderer, J., & Frewer, L. J. (2003). The biotechnology communication paradox: Experimental evidence and the need for a new strategy. *Journal of Consumer Policy*, *26*(2), 125–157.

Seifen, N. (2021, August). Apfel4.NULL: Einsatz von sensoren für eine nachhaltige Produktion und Lagerung (pp. 16–17). Besseres Obst.

Siefen, N., McCormick, R. J., Vogel, A. M., & Biegert, K. (2023). Effects of laser scanner quality and tractor speed to characterise apple tree canopies. *Smart Agricultural*

Technology, *4*(November 2022), 100173. https://doi.org/10.1016/j.atech.2023.100173

Sonntag, W. I., Ermann, M., Spiller, A., & von Meyer-Höfer, M. (2021). Im Streit um die Nutztierhaltung: Gesllschaftsorientierte Kommunikationsstrategien für die Agrar- und Ernährungswirtschaft. *German Journal of Agricultural Economics*, *70*(1), 1–16. https://www.gjae-online.de/de/articles/im-streit-um-die-nutztierhaltung-gesellschaftsorientierte-kommunikationsstrategien-fur-die-agrar-und-ernahrungswirtschaft/

Spykman, O., Emberger-Klein, A., Gabriel, A., & Gandorfer, M. (2022). Autonomous agriculture in public perception - German consumer segments' view of crop robots. *Computers and Electronics in Agriculture*, *202*(September), 107385. https://doi.org/10.1016/j.compag.2022.107385

Statistische Ämter des Bundes und der Länder. (2019). *Landwirtschaftliche Betriebe mit Anbauflächen gartenbaulicher Erzeugnisse*. https://www.statistikportal.de/en/node/266

Stefas, N., Bayram, H., & Isler, V. (2016). Vision-based UAV navigation in Orchards**This work is supported in part by NSF awards 1111638, 1525045 and the MnDrive initiative. The authors thank professors Emily Hoover, Cindy Tong and James Luby from the department of horticultural science, University of Minnesota for access to their orchards and useful discussions. We also thank dr. Krishna Doddapaneni for his help with the experiments. *IFAC-Papersonline*, *49*(16), 10–15. https://doi.org/10.1016/j.ifacol.2016.10.003

Te Velde, H., Aarts, N., & Van Woerkum, C. (2002). Dealing with ambivalence: Farmers' and consumers' perceptions of animal welfare in livestock breeding. *Journal of Agricultural & Environmental Ethics*, *15*(2), 203–219.

Treiblmaier, H., & Garaus, M. (2023). Using blockchain to signal quality in the food supply chain: The impact on consumer purchase intentions and the moderating effect of brand familiarity. *International Journal of Information Management*, *68* (April 2022), 102514. https://doi.org/10.1016/j.ijinfomgt.2022.102514

von Veltheim, F. R., & Heise, H. (2021). German farmers' attitudes on adopting autonomous field robots: An empirical survey. *Agriculture*, *11*(3), 216. https://doi.org/10.3390/AGRICULTURE11030216

Weary, D. M., & Von Keyserlingk, M. A. G. (2017). Public concerns about dairy-cow welfare: How should the industry respond? *Animal Production Science*, *57*(7), 1201–1209. https://doi.org/10.1071/AN16680

Weible, D., Christoph-Schulz, I., Salamon, P., & Zander, K. (2016). Citizens' perception of modern pig production in Germany: A mixed-method research approach. *British Food Journal*, *118*(8), 2014–2032. https://doi.org/10.1108/BFJ-12-2015-0458

Wilmes, R., Waldhof, G., Breunig, P., & Uludag, A. (2022). Can digital farming technologies enhance the willingness to buy products from current farming systems? *PLoS One*, *17*(11), 1–20. https://doi.org/10.1371/journal.pone.0277731

Wiseman, L., Sanderson, J., Zhang, A., & Jakku, E. (2019). Farmers and their data: An examination of farmers' reluctance to share their data through the lens of the laws impacting smart farming. *NJAS: Wageningen Journal of Life Sciences*, *90-91*, 1–10. https://doi.org/10.1016/j.njas.2019.04.007

Wolters, E. A., Steel, B. S., Anderson, S., & Moline, H. (2021). The future of food: Understanding public preferences for the management of agricultural resources. *International Journal of Environmental Research and Public Health*, *18*(13), 6707. https://doi.org/10.3390/ijerph18136707

Wuepper, D., Wree, P., & Ardali, G. (2019). Does information change German consumers' attitudes about genetically modified food? *European Review of Agricultural Economics*, *46*(1), 53–78. https://doi.org/10.1093/erae/jby018

Yap, T. L., Nayak, R., Vu, N. T. H., Bui, D. T., Pham, T. T. T., & Allen, D. W. E. (2023). Adopting blockchain-based traceability in the fruit supply chain in a developing economy: Facilitators and barriers. *Information Technology and People*, *38*, 419–441. https://doi.org/10.1108/ITP-02-2023-0168

Yue, C., Alfnes, F., & Jensen, H. H. (2009). Discounting spotted apples: Investigating consumers' willingness to accept cosmetic damage in an organic product. *Journal of Agricultural and Applied Economics*, *41*(1), 29–46. https://doi.org/10.1017/S1074070800002534

Yuksel, H., Karantininis, K., & Hess, S. (2017). Reconsidering media discourses on food crisis from a quantitative perspective. *Journal of Food Products Marketing*, *23*(4), 398–415. https://doi.org/10.1080/10454446.2014.1000449

Zander, K., Isermeyer, F., Bürgelt, D., Christoph-Schulz, I., Salamon, P., & Weible, D. (2013). *Erwartungen der Gesellschaft an die Landwirtschaft*. Thünen.

Zhang, C., Valente, J., Kooistra, L., Guo, L., & Wang, W. (2021). Orchard management with small unmanned aerial vehicles: A survey of sensing and analysis approaches. In *Precision agriculture*. Springer US. https://doi.org/10.1007/s11119-021-09813-y

Zhang, J., Kang, N., Qu, Q., Zhou, L., & Zhang, H. (2024). Automatic fruit picking technology: A comprehensive review of research advances. *Artificial Intelligence Review*, *57*(3), 54. https://doi.org/10.1007/s10462-023-10674-2

Zhang, Q., Karkee, M., & Tabb, A. (2019). The use of agricultural robots in orchard management. In J. Billingsley (Ed.), *Robotics and automation for improving agriculture* (pp. 187–214). Burleigh Dodds Science Publishing. https://doi.org/10.19103/as.2019.0056.14

Zimbelman, R. G., Wilson, L. L., Bennett, M. B., & Curtis, S. E. (1995). Public image of animal agriculture in the United States. *Livestock Production Science*, *43*(2), 153–159. https://doi.org/10.1016/0301-6226(95)00040-R

Appendix

Interview Guideline

Questions for Interviewees

1. How old are you?

(a) <30
(b) 30-40
(c) 41-50
(d) 51-60
(e) 61-70
(f) >70
(g) No answer

2. What gender do you identify as?

(a) female
(b) male
(c) diverse
(d) no answer

3. Which county do you live in?
4. How would you describe the area you live in?

(a) Mostly rural
(b) Mixed
(c) Mostly urban
(d) No answer

5. What is your highest level of completed education?

(a) Primary school
(b) Secondary school
(c) Post-secondary at a university or technical college (e.g. Diplom, Magister, Bachelor, Master, PhD)
(d) Other (please specify)
(e) No answer

6. Do you have a specific training in one of these topics?

(a) Agriculture
(b) Food science
(c) Forestry
(d) Sustainability
(e) Digital technologies (e.g. IT, electrician, engineering, etc.)
(f) Other (please specify)
(g) No answer

7. Where do you get your information about digitalization in fruit production or in your professional field? (multiple responses are possible)

(a) Magazines, newspapers
(b) Social media
(c) Colleagues and neighbours
(d) Agricultural fairs or conferences
(e) Training courses
(f) Other (please specify)
(g) No answer
(h) I do not have any information on digitalization in fruit production or my professional field

8. Please self-grade your knowledge on digitalization in fruit production

(a) High
(b) Rather high
(c) Medium
(d) Rather low
(e) Low
(f) No answer

9. Which role do you play in the digitalization of agriculture? (multiple responses are possible)

(a) Agricultural production
(b) Agricultural advising
(c) Agricultural organization or association
(d) Mechanical engineering
(e) PPP manufacturer
(f) Fruit storage and/or processing
(g) Wholesaler and/or marketing
(h) IT- and digital sector
(i) Administration
(j) Research
(k) Education
(l) Technology development
(m) Local community initiatives or groups
(n) Community service/charitable foundations
(o) No professional/institutional area

10. Which sector do you work in? (multiple responses are possible)

(a) Private
(b) Public
(c) Non-profit
(d) Civil society
(e) Other (please specify)
(f) No answer

Questions only for owners or leasers of farming enterprises

11. Which production system do you use on your farm? (multiple responses are possible)

(a) Integrated production (IP)
(b) Organic production
(c) Certified organic production
(d) Demeter production
(e) No answer

12. How large is your farming enterprise? (answer in hectares)
13. Please provide the main products of your farming enterprise (multiple responses are possible)
a) Plant products

(1) Stone fruits
(2) Soft fruits/berries
(3) Other fruits
(4) Cereals
(5) Other

b) Animal products

(1) Eggs
(2) Milk
(3) Other

c) Services

(1) Lodging
(2) Vacation apartments
(3) Maintenance work for the community
(4) Other

d) No answer
14. Please describe the ownership of your farming enterprise (multiple responses are possible)

(a) Own property
(b) Lease
(c) Community of joint heirs/civil law association/community of farms/cooperative/Ltd
(d) Other form (please specify)
(e) No answer

15. Do you use digital tools or technologies on your farming enterprise?

(a) If yes, which ones? Or rather for which purposes do you use the tools?
(b) If no, why not?
(c) No answer

16 .How do you store your products? (multiple responses are possible)

(a) On-site storage
(b) Off-site storage
(c) Storage in communal storage facility
(d) Storage in commercial storage facility
(e) Other (please specify)
(f) No answer

17. How do you market your products? (multiple options are possible)
a) Direct marketing

(1) Farm shop
(2) Delivery service
(3) Shipping

b) Intermediary trade
c)Wholesaler
d) Communal marketing over e.g. farming cooperative
e) Export
f) Other form (please specify)
g) No answer

Challenges in fruit production (your farming enterprise/the Lake Constance region)

18. Describe the most important environmental challenges of fruit production in the Lake Constance region
a) Do these differ from those in organic fruit production?

(1) If yes, which challenges differ, and what are the reasons for these differences?

b) Are there differences based on farm size?

(1) If yes, which challenges differ, and what are the reasons for these differences? Please name the farm sizes in hectare for small/large.

19. Describe the most important socioeconomic and social challenges of fruit production in the Lake Constance region
a) Do these differ from those in organic fruit production?

(1) If yes, which challenges differ, and what are the reasons for these differences?

b) Are there differences based on farm size?

(1) If yes, which challenges differ, and what are the reasons for these differences? Please name the farm sizes in hectare for small/large.

20. What do you understand by the term "digitalization in fruit production"? Please give examples. 21. Do you believe that digitalization can help mitigate the previously mentioned ecological challenges? If yes, which challenges and how?
22. Do you believe that digitalization can help mitigate the previously mentioned socioeconomical and social challenges? If yes, which challenges and how?
23. What are the advantages of digitalization in fruit production? a)Do these differ from those in organic fruit production?

(1) If yes, which challenges differ, and what are the reasons for these differences?

b) Are there differences based on farm size?

(1) If yes, which challenges differ, and what are the reasons for these differences? Please name the farm sizes in hectare for small/large.

24. What are the disadvantages of digitalization in fruit production?
a) Do these differ from those in organic fruit production?

(1) If yes, which challenges differ, and what are the reasons for these differences?

b) Are there differences based on farm size?

(1) If yes, which challenges differ, and what are the reasons for these differences? Please name the farm sizes in hectare for small/large.

25. What barriers do you see to the introduction/use of digital technologies and innovations in fruit production?

a) Do these differ from those in organic fruit production?

(1) If yes, which challenges differ, and what are the reasons for these differences?

b) Are there differences based on farm size?

(1) If yes, which challenges differ, and what are the reasons for these differences? Please name the farm sizes in hectare for small/large.

26. In your opinion, would the use of digitalized technologies in fruit production change public opinion about the products or production methods? (Yes, no and what reasons play a role here)

a) Does your answer differ when we speak about the use of digitalized technologies in organic fruit production? (if yes, how and what are the reasons for these differences)

27. Please indicate which of the following groups of people or organizations you think would benefit (winners), not benefit (losers) or neither benefit nor lose (neutral) from the digitization of fruit growing, and add if any should be missing from your point of view (your farm/region).

(a) Organic fruit producers
(b) Conventional or integrated fruit producers

(c) Small to medium sized farms
(d) Larger farms
(e) Fruit wholesalers and marketers
(f) Production cooperatives/associations
(g) Agricultural researchers
(h) Manufacturers of agricultural technologies
(i) Companies in the field of digitalization/digital technologies in agriculture
(j) Consultant for fruit production
(k) Consultant for digitalization
(l) Crop protection manufacturers
(m) Consumers