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## Organizational aspects of digitalization in the context of agriculture: Exemplary results from analyzing data flows in German dairy farming

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### Abstract

The organizational aspects of digitalization in the context of agriculture are embedded in a complex interplay of a market-based economy, sustainability, and information security. In the medium term, digital solutions' success in increasing data transparency and security will depend on organizational adaptation due to value chain-specific data flows. A research project in Lower-Saxony, Germany, is currently applying inter- and transdisciplinary research methods to investigate data flows along agricultural value chains. In the following, the organizational aspects of digitalization of farm businesses exemplified in the value chain of dairy production will be outlined—aligned with current limitations in data processing and sharing based on quantitative and qualitative data available so far.

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## 1. Digitalization in agricultural enterprises

Digitization is playing an increasingly important role in the agricultural industry. Despite numerous advantages, it is also accompanied by challenges that need to be addressed in the medium term. Implementing new types of digital solutions, such as farm management and information systems (FMIS), requires data permeability along value chains. At the same time, the involved actors voice a legitimate interest in preserving their data sovereignty. In general, organizational effects of digitalization have been found on the agility of organizations, the size, shape, organizational learning, digital innovations, and the business ecosystems [1].

In agricultural businesses, a conflict between data transparency and data security plays a decisive role, resulting in the demand for protected transparency. This is primarily addressing the challenges within and in between organizations. In addition, many available solutions are based on proprietary software, reducing the general quality of data flows.

Furthermore, there is growing external pressure on agricultural businesses to produce by the growing demands for sustainability in a strongly market-oriented system. Whether and to what extent digitization positively impacts the organization itself, and the social, economic, and ecological sustainability of the agricultural organization itself has not yet been sufficiently researched.

This line of reasoning frames the research activities of an inter- and transdisciplinary research project whose focus lies on a holistic consideration of digitalization potentials in Lower Saxony's agriculture. Historically, some regions have developed into clusters of economically well-positioned, export-oriented agricultural industries. In one of the project's work packages, all relevant data flows occurring alongside agricultural value chains, for instance, for dairy production, as well for broilers production and pig fattening, including the stakeholders involved, are collected and analyzed according to their innovation potential for the organizations themselves but also in the interfaces of the value chain.

At the conference, the research mentioned above will be presented to raise awareness of the opportunities and risks of digital innovation along agricultural value chains against data security and transparency. The value chain of dairy production will be portrayed to show the data flow and the problems of information sharing and migration of processes. In this presentation, we want to elaborate on the impact of digitalization in the agricultural business of dairy farming.

## 2. Digitalization in German agricultural businesses – challenges and opportunities

Digitalization is one of the megatrends in agriculture and agribusiness and affects all actors in agricultural value chains - including production, processing, food retailing, and the consumer [2,3]. Above all, potentials for efficiency and productivity increases are frequently referred to in this context [4]. However, digitization in agriculture faces the same challenges as in other domains. These include barriers to acceptance or a lack of interoperability among nodes of value chains [5,3]. In addition, there are media discontinuities, so that, for example, operational data may be collected and processed digitally but ultimately has to be transmitted to third parties in analog form (e.g., by fax or by mail). Digitalization is also very relevant in the context of sustainability [6,7,8]. Some authors [9] even emphasize that Digitalization could be a tool to solve the diverse challenges in environmental protection and world nutrition.

Other studies examine the problems of agro-industrial digitalization as determinants for the competitiveness of entire agro-industrial systems, for example, in Russia [10]. Other authors [11] focus on the aspects of innovative development in milk cattle breeding by using digital technologies in data management to stimulate science and technologies, the purpose of the implementation of digital technologies was the acceleration of processes of the innovative development in the industry in milk cattle breeding. Also, critical voices are raised that the literature on digitalization in agriculture mainly focuses on the technical aspects of improving agricultural practices and productivity [12].

Despite the opportunities of digitalization, it is also accompanied by problems [13,14]. Data security and transparency is a prominent issue in digitalization's discourse [15,16], which has special significance when applied to agricultural data flows [17,18]. Many digitalization processes in agricultural production can only be carried out successfully if data leaves the farm and is exchanged between different actors along value chains (transparency). On the other hand, there is a legitimate interest in ensuring that data sovereignty remains with its originators. Possible solutions to this conflict of interest are discussed in the discourse of "protected transparency," which is gaining momentum in German academia [19,20,21]. The field mentioned above of tension is further underpinned by increasing qualifications needed to properly handle digital data management [22] and upheavals in the organizational structures

of farms [23,24]. This, in total, may result in conflicting goals between the implementation of digital solutions and the sustainability dimensions (economic, ecological, social) of agricultural production.

Overall, digitalization in the domain of agriculture is considered to be particularly complex [9]. Thus, a comprehensive treatment of digitalization must address the interests of a broad and heterogeneous group of stakeholders more than in other domains: farmers, service providers, machine manufacturers, and food processors - but also a large number of interested citizens in their possibly conflicting roles about the evaluation of agriculture; for example, as consumers, inhabitants of rural areas, taxpayers and employees in agri-businesses.

Since digitalization of agriculture is characterized by the comprehensive networking of machines, processes, and actors within value chains, Land management (soil cultivation, sowing, crop protection, harvesting) and animal husbandry (feeding, vital data monitoring, use of medicines) are subject to processes of automation and mechanization. These trends are often subsumed under smart or precision farming [25]. The organizational aspects of digitalization in literature are discussed under organizational agility, which is necessary in a fast-paced world and a long-term advantage [26]. It is also responding to environmental challenges. Furthermore, the organizational structures measured by the number of employees are concerned [27].

As mentioned above, information is more accessible and transparent. The aspect of organizational learning of companies to enable innovation and process effectiveness [28] plays a decisive role in agricultural businesses. The new information must be transformed and adapted to the company's context. Digital innovations enable digital technology and are embedded into traditional products [29]. New types of rapid and unpredictable innovation processes require companies to have agile technologies, organizational structures, and cultures to cope with the fast innovation cycles. Digitalization enables business ecosystems to interact and communicate fluently with each other. It, therefore, plays in developing business ecosystems and cooperation, which can be observed in the dairy farming value chain.

### **3. Mixed-methods as a means to approach organizational changes**

To better comprehend the interplay between digitalization and organizational features of German dairy farms, a mixed-methods approach was chosen, which combines quantitative and qualitative methods [30]. The starting point of the chosen methodological approach was implementing a quantitative online survey aimed at analyzing the degree of automation of internal and external data flows and the stakeholders involved. Due to the overall thematic complexity, a low-threshold approach was deliberately not chosen. Instead, the survey's content and scope were designed to ensure the participation of interested experts [31].

The data flows of the dairy farms that participated in the online survey are presented as an exemplary case study. The farms are characterized by an average livestock population of 122 dairy cows, making them quite representative in terms of their size structure compared to the Lower Saxony average of 105 dairy cows per farm according to the 2020 agricultural census. Based on the findings of an online survey and interviews with farmers of all three value chains were conducted [32]. By this approach, opinions and experiences were brought to the fore in addition to the online survey's quantitative data [33]. The analysis of the interviews is based on the principles of qualitative content analysis [34]. This approach ensures that organizational changes can be traced based on quantitative data and assessed from the farmers' perspective.

### **4. Digitally induced organizational changes on German dairy farms**

The structural changes in German agriculture that have been taking place for several decades are embedded in a complex interplay with current digitalization trends. Viewed on a large scale, the number of farms throughout Germany has been in sharp decline for 50 years now. This trend is essentially a reaction to technical progress on the one hand and changes in the price-cost ratio in agricultural production on the other [35]. Digitalization could be the next step in the ongoing mechanization and capitalization of the agricultural output [36]. This would inevitably have profound organizational effects. On the other hand, digitalization can also be interpreted as a catalyst toward sustainable means of production [8] and organizational agility in complex economic systems [26]. Hence, in the following, quantitative and qualitative data will be analyzed to highlight the currently observable effects of digitalization on organizational structures on German dairy farms.

Dairy farming in Germany is characterized by a sequence of complex steps, each shaped by different technical and organizational factors. Public and private stakeholders closely accompany each step along the value chain. The value

creation process is monitored in its entirety by governmental agencies, such as veterinary offices, and accompanied by breeders and professional associations as well as advisory services (see Fig.1).

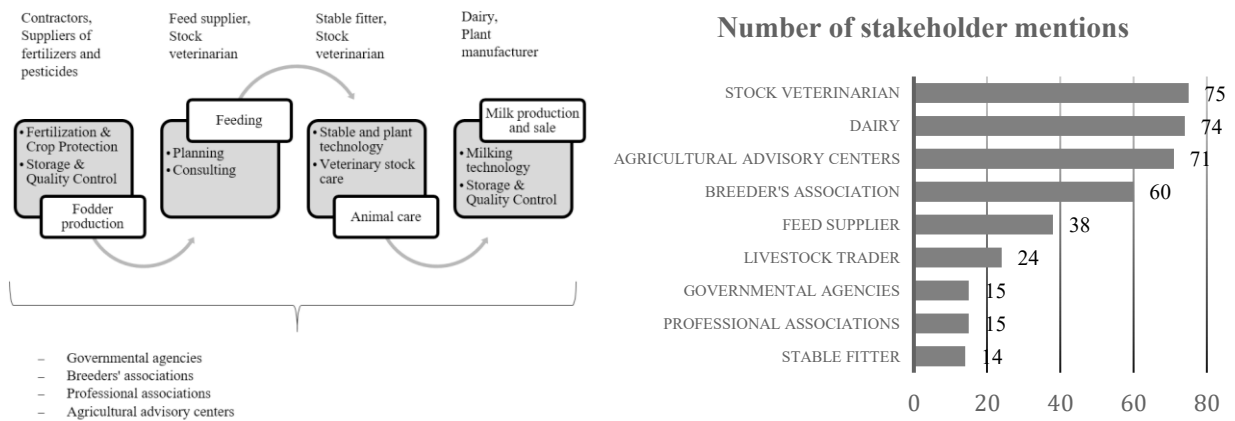


Fig. 1. Schematic overview of the dairy farming value chain (left) and number of stakeholder mentions in the online survey (n=10), sources: own data.

Based on the dairy farmers who participated in the online survey, stock veterinarians and dairies play a significant role since they are responsible for monitoring animal welfare, improving milk yield, and monitoring the milk's quality. Cooperation with the relevant stakeholders is closely linked to collecting, storing, and sharing various data types.

To date, many German farm management information systems (FMIS), such as the Agrirouter [37] or 365FarmNet [38], are focusing on achieving an automated collection and transmission of telemetric data (e.g., application data, harvest and yield data, process data, soil data). The aim is to increase productivity and efficiency by networking agricultural machinery with intelligent software solutions.

However, most medium-sized dairy farms perform most of the labor by family members. This means that workflows and the exchange of information are traditionally organized informally. For most farmers surveyed, the most immediate impact of digitization on these informal workflows was the use of messaging services, such as WhatsApp, to facilitate the exchange of information daily:

*"Yes, there is already an improvement in work management. But there is still a lot to be done. If you want to call WhatsApp digitalization now, it already has an enormous influence. [...] We also use Microsoft Outlook and Excel documents, for example. [...] That already has a big influence on daily interaction."* (expert interview 4)

This example illustrates that currently, the most significant internal organizational changes on medium-sized dairy farms do not result from the implementation of sophisticated FMIS but the use of low-threshold services.

However, external organizational changes are driven by digitalization's impact on collaboration with stakeholders. On dairy farms. Collaboration is the strongest with stock veterinarians and dairies (see fig. 1). When considering the degree of digitalization or automation of the value chain-specific exchange of farm data with these specific stakeholders, it is noticeable that the collection of animal-related data (breeding values, milk yield, milk quality data, vital data) in particular is already subject to a high degree of automation:

*"Digitalization also plays a role in milk quality assessment. Everyone can access the Milkmaster program at DMK [Deutscher Milchkontor; Germany's largest dairy cooperative]. And so you can also call up the milk quality evaluations yourself every time."* (expert interview 2)

In addition to internal and external organizational changes, it can also be noted that digitalization may function as a means to diversify the farm's venues and thus add to its organizational agility [1]. Innovative examples, such as the CrowdFarming initiative [39], illustrate that digitalization holds the potential to reconnect farms and consumers, alter value creation systems and empower farmers in their organizational learning.

Surprisingly, most interviewed farmers stated that they have either thought about using digital means to diversify their venues in the past or are currently doing so. One dairy farm, for example, has integrated a small-scale cheese factory into its business operations, with social media playing a significant role in its regional marketing.

## 5. Organizational aspects of digital transformation in agricultural value chains of dairy businesses

The digitalization in agriculture is embedded into various structural changes in the agricultural business itself. Different external stakeholders in production, trade, and processing benefit from an increasing technical integration into value chains [3]. At the same time, the organizational features of the farm itself are impacted by digitalization at the very moment [1]. Thus, analyzing organizational changes in agricultural production needs to consider technical feasibilities, farmers' needs, political regulations as well as the interests of other stakeholders.

Considering this, the research described above collects data on dairy farming organizational changes due to digitalization and innovative development within the value chain. We were focusing not only on the technology but also on the aspects within and between the organizations regarding security and transparency. With a specific focus on the organizational aspects of digitalization within dairy production, we observed organizational changes in the agility of the enterprises, within the internal structures, regarding organizational learning, embedded digital innovations, and the interaction within the business ecosystem. It must be in the shared interest of all stakeholders to avoid "analog absurdities," such as printing out digital data to transmit them by mail or fax [5].

It has been shown, especially regarding animal welfare monitoring, that veterinarians play a decisive role. Focusing on the internal organizational aspects, the exchange of information was organized informally here, and messaging services such as Whatsapp played an essential part. External organizational changes like the business's ecosystem and the stakeholders' collaboration are based on a high degree of automatization. However, there are some interface challenges and innovation potentials observed. An important aspect is the diversification of farms in terms of organizational agility and shows the organizational learning of the domain. Stakeholder acceptance problems or interoperability at nodes of the value network and interface problems or media discontinuities must be addressed from multiple perspectives. As an outlook, it can be formulated that criticism of agricultural production and the focus on technology must be included in the debate. Digitalization as a catalyst towards sustainability means considering the complex steps of the value chain and the different stakeholders involved, monitored by governmental agencies.

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