DIGITAL GROUND:

A MASTER'S THESIS PROJECT FOR NAVIGATING THE OPPORTUNITIES OF DIGITAL TRANSFORMATION IN AGRICULTURE

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Abstract

This thesis embarks on a techno-anthropological investigation into the digital transformation of agriculture, adopting a phenomenological lens to examine the cultural and social dimensions of technology adoption among farming communities. Utilizing a case-study design, this thesis critically engages with the lived experiences of stakeholders—farmers, technology developers, and agro-tech transformation experts—to unearth the socio-cultural dynamics that underpin the adoption and use of digital technologies in agricultural settings. Drawing upon theories of technological diffusion and socio-technical systems, this thesis identifies the barriers and facilitators that shape the digital landscape in agriculture. These include socio-economic challenges, cultural resistance, infrastructural limitations, and varying degrees of technological literacy based on real-world contexts. The findings highlight the complex, often contentious negotiations that occur as traditional agricultural practices intersect with emerging digital innovations.

By weaving together empirical data with theoretical insights from techno-anthropology, the thesis offers a nuanced understanding of how digital tools are embedded within, and potentially reshape, agricultural communities. It argues for a more culturally sensitive and participatory approach to technology policy and design that recognizes the diverse values, needs, and practices of agricultural stakeholders. This study not only contributes to academic discussions on technology adoption but also provides practical recommendations for fostering more inclusive and effective digital transformation strategies in agriculture.

Contents

1. Introduction

In recent years, digital technologies have caused a significant transformation in the agriculture industry. Digitization has transformed traditional farming methods, bringing new challenges as well as efficiencies, and it is considered a major aspect of the larger trend towards precision agriculture. Cutting-edge technologies like GPS, sensors, and data analytics have not only optimized resource management but also completely transformed the decision-making processes of farmers and other industry stakeholders, introducing new commercial service providers to the sector.

Beyond simple operational improvements, digital tools are vital to agriculture because they help solve global issues like environmental preservation, food security, and sustainability. Yet, there are significant differences in the adoption and successful diffusion of these technologies among various agricultural stakeholders. A variety of variables, including cultural and economic ones, contribute to these differences, and their unpredictability creates a complex digital transformation scenario in agriculture, hindering adoption among farmers.

Through semi-structured interviews and ethnographic fieldwork with different stakeholders in the agricultural sector, this case study intends to reveal the main barriers and facilitators of technology adoption by investigating how digital technologies impact the lived experiences and perceptions of those involved. Furthermore, it uses the theoretical frameworks of Izek Ajzen's Theory of Planned Behavior and Everett M. Rogers' Diffusion of Innovation to examine the implications of these processes for the adoption and diffusion of digital technologies in the agricultural sector. Through this exploration, the thesis will provide insights into the socio-technical processes of digitalization in agriculture, with the goal of offering a nuanced understanding of how digital tools impact operational efficiencies and sustainability. The thesis' findings aim to contribute to the ongoing discourse in digital agriculture, providing stakeholders with a clearer understanding of how to navigate the challenges and opportunities presented by digitalization through a conceptual framework grounded in real-world contexts.

2. Background

In the following chapter, the background for digitalization in agriculture, offering a concise overview of the field and its various technologies. Additionally, the elements of barriers and facilitators for adoption will be introduced. After that, the chapter will present the state of the art of digitalization in Denmark, highlighting the challenges the country faces. As this thesis is centred around the different barriers and facilitators there are for adoption, they will also be introduced. Lastly, a thorough literature review will be conducted to understand the situation of digital agriculture today. This will aid in scrutinizing the next section of the thesis statement that follows.

2.1. Digitalization of Agriculture

The integration of digital technologies in agriculture represents a transformative phenomenon, reshaping traditional farming. However, his shift encompasses not only Precision Agriculture (PA) but also a broad spectrum of complementary digital technologies that enhance decision-making and operational efficiencies. These technologies extend from mobile applications for decision support to advanced drones and robots that automate agricultural operations, as well as service-oriented IT support, illustrating a significant evolution in agricultural practices (OECD, 2019). The digital transformation here, reflects the socio-technical processes that emerge from the strategic use of digital technologies in agricultural practices, and digitalization continues to evolve into decision-making support tools for practitioners, facilitating site-specific and efficient processes in both livestock and crop farming (Nambisan et al., 2017). PA is primarily related to digital on-farm activities, but digitalization also encompasses complementary digital technologies that broaden the spectrum of applications and interconnect farmers with other farm systems or value chain stakeholders (Rolandi et al., 2021). As digitalization within the agriculture sector has increased exponentially over the last few years, so has the research investigating the adoption and use of these technologies.

Digitalization facilitates, that farmers can access real-time data on soil moisture, crop health, weather conditions, and pest infestations, enabling more informed decision-making and precise management practices (Gabriel & Gandorfer, 2022). This results in increased efficiency

and yields, but also reduces the environmental impact of farming by minimizing the use of water, fertilizers, and pesticides.

There are many benefits to digital tools, as underscored in a report by the GAO (2024), where they highlight; lower operational costs, improved safety, quality of life for farmers, and significant reductions in CO2 emissions (GAO, 2024). In addition to PA technologies, digitalization in agriculture also entails complementary service systems companies such as Terra Connect[1], defined as technology providers that provide essential support and services that enhance the functionality and accessibility of digital tools in the field, thus encompassing smart digital technologies for data collection, decision making and analysis (Tey & Brindal, 2012). Furthermore, it is equally important to examine how these technological changes affect the daily experiences and operational realities of stakeholders, from small-scale farmers to large agribusinesses, and identify the key barriers and facilitators influencing their decision to adopt these innovations. In the article "Digitalisation of the European Agricultural Sector" (Translated to English) from the European Commission (2020), the European Commission outlined the pros and challenges of the application of digital tools in agriculture (The table is from their website and has been translated to English):

[1] https://terraconnect.dk/

Table 1 - Pros and Challenges of digitalization in agriculture from the Europa Commission website (Translated to English)

Pros	Challenges
Increased economic and environmental performance: Digitization can help farmers make better decisions, optimize their operations and increase productivity, leading to higher profits and a more sustainable agricultural sector	**Connectivity issues:** Many rural areas still lack reliable and affordable internet access, hindering the adoption of digital technologies
Environmental sustainability: The use of digital technologies can help farmers reduce their environmental footprint by optimizing resource use, reducing waste and using precision farming techniques	**Limited awareness of benefits:** Many farmers may not be aware of the potential benefits of digitization and may lack the necessary skills and resources to implement new technologies.
The competitiveness of the EU's digital supply industry: Digitization can help the European agricultural sector remain competitive in the global market by providing innovative solutions and creating new business opportunities.	**System compatibility:** Different digital platforms may not be compatible with each other, making it difficult to share data and integrate different applications
Better working conditions for farmers: By automating tasks and optimizing operations, digital technologies can help reduce the physical and mental workload of farmers, leading to better working conditions	**Farmers' skills:** Many farmers may lack the necessary digital skills to fully benefit from digitization
Increased transparency throughout the supply chain: Digitization can help improve the traceability and transparency of agricultural products and enable consumers to make more informed choices	**Benefit-cost ratio:** The costs of adopting new digital technologies can outweigh the potential benefits, especially for small farmers.
	Reluctance to share data: There may be concerns about data protection and ownership, which hinders the exchange of data between different players in the agricultural sector.

The European Commission states (2020) that the application of digital tools in agriculture can provide several benefits for the farmers, but acknowledges that despite these benefits, it will also introduce several challenges that needs to be addressed. They concluded the article by stating that: “To ensure that digitization is inclusive and accessible to all, it is important for policy makers, industry leaders and technology providers to work together to promote the benefits of digitization and support farmers with training, resources, and incentives to adopt new technologies”. (The European Commission, 2020, Translated to English).

2.2. Digitalization of Agriculture in Denmark

Denmark has over the years seen an increasing number of possible accesses to digital applications and PA technologies, and with this evolving landscape of agricultural practices, PA has emerged as a new way to innovate and optimize, offering solutions to the challenges faced by the modern farming sector, and the adoption of digital solutions in agriculture has been increasing, as evidenced by the significant rise in the utilization of precision technologies (Danmarks Statistik, 2022). In 2022, precision agriculture technologies were employed to cultivate 76% of the Danish agricultural land, a slight increase from 73% in 2022, and a notable jump from 57% in 2018. This upward trend underscores the growing recognition among farmers of the value brought by these technologies in enhancing productivity and sustainability.

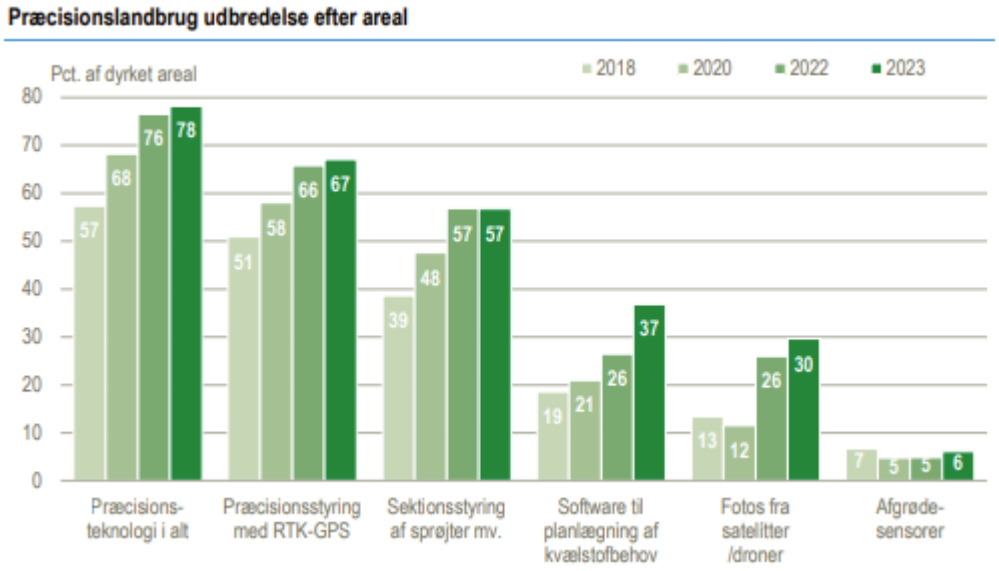

Figure 1 – Precision agriculture – diffusion after area from DST.dk

The adoption of precision agriculture is though applied across all demographics within the farming community, it is predominantly favoured by larger operations, with farms utilizing precision technologies averaging an area of 179 hectares, in contrast to the national average farm size of 92 hectares in 2023. Furthermore, the age and educational background of farmers play a significant role in the adoption rates of these technologies. Young farmers, particularly those under the age of 40, are more likely to adopt precision farming methods, with 62% employing these technologies in 2022. This trend is reflective of a generational shift towards more technologically savvy and educated agricultural practitioners who are more open to embracing new innovations to drive their farming operations forward. Additionally, another

concern in Danish agriculture is that the statistics show that from Danmarkstatistik.dk (Danmarks Statistik, 2022) 2010 to 2020, the average age among farmers has risen from 49.2 to 53.6, which makes one speculate if digitalization can help with the workload.

As stated, there are many benefits to adopting digital tools in agriculture. However, there are also barriers to adopting digitalization tools within the agricultural communities. It is therefore crucial to examine this issue with a nuanced lens and understand the perspectives of farmers and other stakeholders. As pointed out in the GAO report (2024), it may require additional education and training opportunities to successfully use precision agriculture technologies. Financial incentives, training programs to enhance digital literacy, and the development of more cost-effective, user-friendly technologies that align with farmers' operational realities could be key facilitators to drive the digital transformation. Furthermore, this study points to a broader trend of increasing farm sizes and the shifting towards more corporate farming practices, which could potentially facilitate greater investment in digital technologies.

In an article called “The agricultural sector isn’t particularly digital. Why is that?” by Aarhus University (Bruun, 2021), the expert in agro-technology, Claus Grøn Sørensen, says, “This is absolutely necessary when we look towards the future. In 2050, we’ll have to produce 70% more food to feed the world’s population, and we also have a responsibility to reduce the climate and environmental impact of this food production. This applies across national borders. Digital technologies are simply crucial if we are to have chance at achieving this” (Bruun, 2021). So how can the technology be introduced and how can we identify how new technology best creates value for farmers and the environment. Claus additionally add: “In some cases, the technologies have arrived too soon and aren’t ready to be incorporated into the agriculture. In other cases, the technologies may have been too complicated to use, or the cost of implementing the technologies was perhaps too high compared with the immediate benefits. But the technologies have evolved since then, and there are currently many green, modern and mature agricultural technologies available that could benefit in a wide range of area,” (Bruun, 2021).

Digitalization in agriculture not only transforms operational efficiencies, but also addresses significant environmental challenges faced by the sector. Recent reports on the degradation of ecosystems such as Hjabæk Fjord underscore the environmental pressures of traditional farming methods (Lund et al., 2023). Agriculture is under increasing public and governmental pressure to adopt greener methods due concerns about its environmental

footprint, notably its contribution to CO2 emissions, grow. The Danish Society of Nature Conservation (In Danish: Danmarks Naturfredningsforening) reports indicate, that if significant changes aren't made, agriculture could account for a 46% of Denmark's overall emissions (Bentsen, 2024). This reflects a strong public and governmental interest, in promoting environmental accountability and sustainability, and a carbon-tax may be implemented if something doesn't happen. However, some may argue, that this carbon-tax can also serve as a critical incentive for the agricultural sector to adopt digital technologies that can help meet these new regulations more effectively.

The debate over implementing a carbon-tax, highlighted in the 2024 reports by the Danish Society of Nature Conservation (Bentsen, 2024), illustrates the intricate balance between economic incentives and environmental responsibilities. This facilitates a discourse that influences both academic and public spheres and may indicate a strong momentum towards adopting digital tools that not only comply with environmental regulations but also bolster sustainability practices (Bentsen, 2024). As noted in the article "Experts before bid on CO2 tax: Two technologies can make agriculture more climate-friendly" (Lillevang, 2024, translated to English), they state "Once a final tax model is politically established, attention must shift to technologies that mitigate the climate impact, thereby easing the tax burden on individual farms". This statement underscores that the technologies, such as Bovaer[2] which reduces methane emissions from livestock, are available. Experts emphasize that although there is a significant potential for these technologies to lower CO2 emissions, societal acceptance among farmers, is considered a barrier to the widespread adoption of digital tools. (Lillevang (2024).

Some of the key strategies concerning the adoption and diffusion of digital tools in agriculture are highlighted in a 2014 study by the United Nations Framework Convention on Climate Change. The study emphasizes the critical importance of bottom-up and participatory approaches in adapting agricultural technologies to meet local needs effectively. It brings up the argument, that such approaches must be integrated within the community to ensure that the innovations are not only adopted but also sustained over time.

The study further notes the essential role of effective communication and robust knowledge management systems in supporting these initiatives, and for farmers, the ability to

[2] Bovaer is a feed supplement that reduces enteric methane emissions, contributing to a significant reduction of the environmental footprint

access ongoing support and educational resources is considered necessary if they are to be adopted (United Nations, 2014). This includes training on interpreting climate forecasts and other data-driven insights that digital tools provide, which can significantly enhance their decision-making processes, and by empowering farmers with the knowledge to utilize advanced technologies, these tools can lead to improved agricultural productivity and sustainability. Furthermore, the framework implies that the inclusion of farmers early in the process of developing and implementing these technologies can result in more specialized and, consequently, efficient solutions. Therefore, the farmers involvement from the get-go guarantees that the tools are built with a practical grasp of the agricultural setting and established practices, improves the technologies' relevance and usability.

2.3. Literature review of research on technological adoption among farmers

The adoption and diffusion of digital farming technologies involve complex interactions at both individual farm levels and within broader agricultural systems, and in this section, literature findings will be presented to gain an overview of the current state of adoption of digital technologies in agriculture and present the knowledge gap that exists. The literature search was conducted using Scopus[3] - an abstract and citation database - and using terms of agriculture, precision, digitalization in different formations.

Recent research highlights diverse factors influencing technology adoption among farmers. Michels et al. (2019) investigate smartphone use within German agriculture, linking technological literacy to higher adoption rates. Salimi et al. (2020) analyse farmers' perceptions of the utility and usability of smart farming tools, noting these perceptions significantly impact adoption decisions. Caffaro and Cavallo (2019) identify major adoption barriers, such as perceived high costs and uncertain investment returns. Similarly, Drewry et al. (2019) focus on barriers to digital technology adoption among crop, dairy, and livestock producers in Wisconsin, emphasizing the necessity of external support and accessible knowledge for overcoming these obstacles.

Alexander et al. (2013) discusses how the broader agricultural system—comprising various stakeholders including technology providers and regulatory bodies—shapes technology diffusion. They assert that both individual farmer behaviours and their

[3] https://www.elsevier.com/products/scopus

interactions within this network are crucial for the successful integration of new technologies. Among the studies exploring the impact of neighbours' information and opinions on farmers' adoption decisions, Alexander et al. (2013) provide a significant contribution. Their research models how farmers' interactions with neighbours and the broader community influence their willingness to adopt new agricultural technologies. They find that peer influence often plays a crucial role in adoption decisions, as farmers are more likely to adopt new technologies when they observe successful implementation and positive outcomes among their peers.

Regarding psychological influences, Kaufmann et al. (2009) offer valuable insights into how farmers' attitudes and subjective norms shape their technology adoption behaviours. Their study employs cognitive models to demonstrate that farmers' perceptions and mental attitudes significantly impact their decision-making processes. While farm characteristics are considered, the psychological triggers such as perceived benefits and peer endorsements predominantly drive the adoption of new technologies. Additionally, Reichardt and Jürgens (2008), mentions how “time consuming and “high-initial investment, are some of the most mentioned barriers. While Adrian et al., (2005), introduces, that increasing productivity is seen as a facilitator, while a barrier is the time it takes for handling data.

According to OECD (2019), the agricultural sector needs to adapt to a host of mounting challenges including climate change, and broad environmental degradation, farmworker shortages, rising population levels, and dietary transitions. Digital technologies, including conventional precision agriculture technologies and complementary service providers, are expected to help being a crucial part of the solution to these challenges. Digital farming technologies, including artificial intelligence (AI), cloud computing and the Internet of Things (IoT) will play a bigger role in sustainable agriculture in the future (Walter et al. 2017). It is therefore vital to look at how new technologies are embraced and dispersed throughout the farming industry as they continue to advance and have the potential to upend conventional farming methods.

It is therefore a notable difference that changes how we traditionally see digital transformation, because previously we may have only considered the technological advancements that can improve the production and sustainability. But in terms of this thesis, there is an important distinction to make as I want to acknowledge the user-perspective and how it influences them and their daily practice. It is a matter of creating circumstances where the individual farmer has the best prerequisites to succeed. The insights gained by farmers and

technology providers first-hand experience with these technologies may uncover a deeper understanding of the factors influencing the technologies in agriculture, as it is essential to examine the balance between the recognized need for digitalization to ensure the sector's sustainability and the barriers that prevent its widespread adoption.

This thesis will use empirical techniques like ethnographic fieldwork and in-depth stakeholder interviews to directly address the digitalization of agriculture. Through the incorporation of primary data from farmers, subject-matter experts, and technology decision-makers, the study offers a comprehensive and grounded viewpoint that can guide and improve the creation of the field. This empirical method not only improves our comprehension of the practical adoption of digital farming technologies, but it also offers insightful information that can close the current gap between theoretical models and actual agricultural digitalization. The purpose of this thesis is thus to create a conceptual framework based on empirical findings and facilitate knowledge about adoption and diffusion processes to inform decision-makers in the sector trying to foster implementation for digital technologies. All of the above leads to the thesis statement:

2.4. Thesis statement

How does the digitalization of agriculture influence the adoption and diffusion of digital tools among various stakeholders, and what are the implications of these processes for the integration and effectiveness of such technologies in improving agricultural practices?

Research Questions

1. *How does digitalization in agriculture shape the lived experiences and perceptions of different stakeholders within the agricultural community*?

2. *What are the main barriers and facilitators to the adoption of digital tools by different agricultural stakeholders?*

3. *How does economic, social, and regulatory factors impact the successful adoption and effectiveness of digital technologies in agricultural practices?*

3. Scientific theory

This chapter explores phenomenology and its relevance to the thesis, which centres around the phenomenon of digitalization within agriculture. It begins with an outline of the historical context and fundamental concepts of phenomenology. The use of phenomenology to this research will then be discussed, highlighting the particular factors that must be considered in order to explore digitalization in agricultural contexts via stakeholder perceptions and lived experiences.

Phenomenology is a methodological and philosophical approach that seeks to understand and explore how human beings experience the world directly, emphasizing the subjectivity of perception and the centrality of human experiences. Phenomenology originates from the early 20th century and was mainly developed by Edmund Husserl and later expanded upon by his student Martin Heidegger (Egholm, 2015). Husserl's exploration of conscious experiences and the concept of intentionality, where experiences are always directed towards "something" and experienced by a subject, sets the foundation for understanding phenomenology's applicability to studying digitalization's impact on agriculture.

Fundamentally, phenomenology studies the "phenomena" as seen through a first-person perspective, which in this thesis is "Digitalization" and how it unfolds in agriculture. Using a technique called *epoché*, or phenomenological reduction, this method entails a thorough analysis of the participant's experiences to extract the essence of those experiences while putting prejudices and preconceptions aside (Egholm, 2014). This technique is therefore used to uncover the lived experienced of stakeholders affected by digitalization, from farmers to technology providers.

In applying phenomenology to this thesis, the focus is on understanding the nuances of digitalization from the perspectives of those directly impacted. This includes how digital tools influence daily activities, decision-making processes, and overall perceptions of technology in farming. The methodology involves qualitative techniques such as semi-structured interviews and ethnographic fieldwork. This is done to capture detailed personal experiences and the meanings individuals attribute to them, where the information will get digested through a thematic analysis of interview data and will help illuminate the subjective interpretations of digitalization by different stakeholders in the agricultural community. To avoid oversimplifying complex phenomena, the phenomenological approach is utilized to gather comprehensive, contextualized data about people's everyday lives and routines, ensuring a deeper and more accurate understanding of the subject matter. According to Egholm (2014),

this research fits with phenomenology's emphasis on comprehending the essence of experiences without preconceived notions because it takes a non-prejudicial attitude and lets the phenomena unfold itself through in-depth narratives.

Furthermore, phenomenology aids in creating a conceptual framework that accounts for the various experiences and adaptations necessary amidst digital transformation. This involves considering the strategies that both technology providers and society can implement to encourage the adoption of new technologies, especially those aimed at reducing CO2 emissions. It also involves ensuring that policies and regulations reflect the lived realities of those on the ground—primarily farmers—whose lives and livelihoods are directly influenced by these changes.

The approach taken here does not isolate individual experiences but rather integrates them into a collective understanding, although not reducing them to a singular voice, and thus upholding the phenomenological tradition. Each narrative serves as an individual case study that reflects broader trends and patterns, providing insight into systemic changes and their differential impacts on individuals. This synthesis of micro (individual) and macro (collective) perspectives allows for an examination of digitalization's effects, guiding more informed decisions in agricultural practices and policies. This approach will be further delved into in the analysing strategy.

4. Methods

In this chapter, I will outline introduce the case-study, detailing the qualitative research design, data collection methods (semi-structured interviews and ethnographic fieldwork), and thematic analysis techniques. Lastly, I will introduce the participants that are selected for this thesis.

4.1. Case-study

This thesis incorporates Flyvbjerg's article "Five misunderstandings about case-study Research" (2006) to gain an overall understanding of case-studies, but also to increase the validity and applicability of this research. By applying Flyvbjerg's corrections of misunderstandings concerning the case-study, it offers a nuanced way of explaining the intricacies of the case study, while also providing a framework for the qualitative research design. Flyvbjerg's article is supplemented by Robert E. Stake's methodology of the "collective case-study" (Crowe et al., 2011).

Within the context of this thesis, the use of the case study methodological approach is to gain an understanding of the adoption and diffusion of digital technologies in agricultural farming practices through real-life contexts thus also aligning with phenomenology. This idea is predicated by Flyvbjerg as he emphasizes the value of gaining a deep, contextual understanding through immersive engagement with the subject matter. Such an approach is in line with Flyvbjerg's claim that case studies are effective at capturing the complexity of phenomena in their natural surroundings, providing a deep, nuanced understanding that goes beyond what can be expressed by typical quantitative metrics.

1st Misunderstanding.

Flyvbjerg emphasizes the importance of case studies by highlighting that "Concrete experiences are best gained through close proximity to the subject matter and feedback from participants. Distance and lack of feedback can lead to stagnant learning processes and unclear research outcomes."(2006). He argues against relying solely on quantitative methods, which can create a disconnect between research findings and the actual experiences of subjects, thus diminishing the relevance of the research to real-world complexities. Instead, this thesis leverages interviews and short-term ethnography, allowing for intimate interaction with the subjects. This approach fosters a dynamic feedback loop, continuously refining insights and deepening understanding of the participants' perspectives

within their social and cultural contexts. Flyvbjerg criticizes the limitation of human behaviour to rule-governed acts, advocating for a richer, more nuanced understanding of reality through context-dependent knowledge. He concludes that:

> "Predictive theories and universals are elusive in the study of human affairs. Concrete, context-dependent knowledge is thus more valuable than the elusive search for predictive theories and universals." (Flyvbjerg, 2006).

2nd Misunderstanding.

Secondly, Flyvbjerg addresses the second misunderstanding, which asserts that "one cannot generalize on the basis of a single case" and thus claims that single case studies are inherently limited in their ability to contribute to scientific knowledge due to their lack of generalizability. He advocates for the analytical generalization where insights gained from a case study are used to refine theories and frameworks. The way this unfolds in this thesis, is through the analysis, where the following discussion will bring in theories to then construct a conceptual framework.

Flyvbjerg highlights the case study's strength in enabling generalization through its rigorous and in-depth approach, even if traditional scientific methods may not always recognize it. By engaging deeply with specific instances, such as the integration of innovations in traditional farming practices, case studies reveal unique insights—often unexpected or "black swan" events—that contribute significantly to the field. These findings enhance the understanding of digital agriculture's impact, informing policy, practice, and future research. Flyvbjerg (2006) criticizes the overvaluation of formal generalization in scientific development, suggesting that the rich, detailed insights gained from case studies are often underestimated but are crucial in fields like digital agriculture were rapid evolution and technological integration present unique challenges and opportunities.

Flyvbjerg finalises the 2nd misunderstanding stating that one cannot generalize based on a single case and the case study cannot contribute to scientific development. He revises it as:

> "*One can often generalize based on a single case, and the case study maybe central to scientific development via generalization as supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas 'the force of example' is underestimated*". (Flyvbjerg, 2005)

3rd misunderstanding

In the third misunderstanding about the case study, it is claimed that the case-study method is most useful for generating hypotheses in the first steps of a research process, while theory building, and hypothesis testing are best carried out by other methods in the process. This misinterpretation adopts the previous misinterpretation's position that it is not possible to generalize from specific instances. Flyvbjerg then simply corrects this misunderstanding as the following: “The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone” (Flyvbjerg, 2005).
In this misunderstanding Flyvbjerg writes about how the generalizability of case studies can be increased by the strategic selection of cases. He provides a table with different kinds of types of selections that serves as different purposes depending on the type of case-study the scientist wants to do.

Additionally, Flyvbjerg recommends choosing cases based on how much utility can be obtained for the goal of the study, usually focusing on those that can best elucidate the larger issues and phenomena being studied. However, this study takes a different approach, motivated by Robert E. Stake's methodology for collective-case studies. Robert E. Stake emphasizes the importance of understanding the issue across multiple cases rather than through a single case to see the diversity and commonalities that a phenomenon presents in different settings (Crowe et al., 2011). In this study on digitalization in agriculture, the case selection strategy diverges from Flyvbjerg's preference for a single, most-illuminating case. The collective case-study is defined as “The collective case study involves studying multiple cases simultaneously or sequentially in an attempt to generate a still broader appreciation of a particular issue.” (Crowe at al., 2011**)** Instead, it embraces Stake’s collective case study approach, which involves studying several cases simultaneously to investigate the phenomenon, allowing for an analysis across various contexts.

This approach is valuable for this research as it seeks to explore digitalization in agriculture from multiple perspectives — farmers, tech owners, and implementation experts— each offering unique insights into the digital transformation process within their specific agricultural practices and environments. By treating each group as a distinct case within a collective framework, the study can assess broader patterns and variations, providing a more nuanced understanding of how digitalization impacts different stakeholders in the agriculture sector. This methodological shift supports the thesis’s aim to conceptualize the lifeworlds of

these stakeholders and generate broader understanding of the facilitators and barriers for adoption.

When it comes to the analysis of the collective case-study, while aligning with the phenomenological framework of this thesis, it is said that the "data collection needs to be flexible enough to allow a detailed description of each individual case to be developed" (Crowe et al., 2011), and subsequentially consider the emerging similarities and differences that occur. Following this, the data will then be organized and coded allowing the key issues, both derived from literature and the empirical findings. When reporting results. while staying true to the qualitative way of being transparent and intersubjective, it is important to provide the reader with enough contextual information of the empiric data gathering, so they can understand the processes that were followed.

4th misunderstanding.

The fourth misunderstanding that Flyvbjerg corrects, regarding the case-study method, is that it "maintains a bias toward verification, understood as a tendency to confirm the researcher's preconceived notions, so that the study therefore becomes of doubtful scientific value." (Flyvbjerg, 2006). These misunderstandings highlight a perception among researchers that, unlike more quantitative approaches, the case-study method is more prone to verification bias than other subjective qualitative methods. According to Flyvbjerg, the case study can focus on actual circumstances and test opinions in direct relation to the phenomena as they manifest in real life. As an example, this thesis adheres to the phenomenological principles while remaining open about the procedures and inductive in the sense that it allows the examples to speak for themselves without discounting theories and preconceptions. Following this misunderstanding, Flyvbjerg revises the fourth misunderstanding as the following:

"*The case study contains no greater bias toward verification of the researchers's preconceived notions than other methods of inquiry. On the contrary, experience indicates that the case study contains a greater bias toward falsification. of preconceived notions than toward verification*" (Flyvbjerg, 2006)

5th misunderstanding.

Flyvbjerg's fifth misunderstanding concerns the idea that it is often mistaken that it is difficult to summarize and develop general propositions and theories on the basis of specific case studies. The primary focus here is on an in-depth exploration of the digitalization of agriculture, utilizing a socio-technical and phenomenological lens to analyse varied

stakeholder perspectives on barriers and facilitators. The misunderstanding is important since the aim of the thesis is to create a conceptual framework built on discoveries that are theoretically and contextually grounded, and to connect these findings to wider societal implications.

This study's scholarly contribution lies in its ability to provide a comprehensive analysis and rich, contextual insights into the intricate interplay between technology and human factors within agricultural contexts. While the primary focus is on these detailed insights, the study also endeavours to use these findings to construct a conceptual framework that links specific discoveries to broader societal implications. By ensuring both depth and wider applicability, this approach addresses and corrects the fifth misconception identified by Flyvbjerg, thereby enhancing the overall objectives of the thesis. Flyvbjerg (2006) concluded the discussion on the fifth misunderstanding with the following correction:

> "It is correct that summarizing case studies is often difficult, especially as it concerns case processes. It is less correct as regards case outcomes. The problems in summarizing case studies, however, are due more often to the properties of the reality studied than to the case study as a research method. Often it is not desirable to summarize and generalize case studies. Good studies should be read as narratives in their entirety".

The integration of case-study methodologies with phenomenology means that the framework allows for exploring the nuanced phenomena of digitalization in agriculture among diverse stakeholders. The case-study design is well-suited for answering the thesis statement because it considers several viewpoints that converge on a common problem, such as the adoption of digital technologies in agriculture and the barriers to their use. Because of this convergence, digitalization in agriculture can be understood holistically, considered the fact that different stakeholders—such as farmers, implementation consultant, and technology providers—may interpret and respond to it differently depending on their respective professions.

4.2. Interviews

In the next chapter, the empirical data gathering process will be introduced, drawing from Brinkmann and Tanggaard's book "Kvalitative metoder"(2020) and their guidelines for semi-structured interviews. Additionally, insights from Spradley's "The Ethnographic Interview" (1979) will be incorporated to guide the interview questions. The interview as a research

methodology will be covered in the first section of the chapter, which will also include an examination of various question formats, transcribing technique, and coding procedure.

Interviews serve as a valuable tool to gain insight into how individuals experience various phenomena in their everyday lives, which in phenomenology, refers to the concept of the lifeworld and is a shared realm of daily understanding and interaction (Brinkmann & Tanggaard, 2020). The primary aim of conducting interviews is to obtain an accurate and detailed account of how specific phenomena are perceived and experienced from the individual's first-person viewpoint. This approach allows for a deeper understanding of personal experiences and the meanings attached to them. The objective here is to develop a theoretically grounded and coherent third-person perspective based on the experiences of the respondents.

Based on this thesis, the goal is to comprehend how the phenomenon of "digitalization" is being experienced and understood among various stakeholders, including farmers, subject-matter experts and technology providers, from a first-person perspective (Brinkmann & Tanggaard, 2020). Hence, the interview is viewed as a medium for communicating human experiences from incidents that occur outside of the interview, during which their perceptions on the adoption of digital technologies will be comprehended. Instead of conducting a large number of interviews, Brinkmann and Tanggaard (2020) advise that it is preferable to conduct a relatively small number of interviews and produce a thorough analysis of them, making them theoretically nuanced and in-depth. This is due to the fact that conducting a lot of interviews may provide researchers with an excessive amount of data, making it difficult for them to analyse and interpret the information in a way that is clear and original. The optimal number of interviews should therefore be determined by evaluating when the content has reached saturation and more interviews are not necessary to obtain more pertinent information, which is why four interviews seemed like the optimal choice.

To perpetuate the points made in the phenomenological chapter about being open-minded and avoiding asking leading questions, it is equally important for the researcher to have a thorough understanding of the subject matter (Brinkmann & Tanggaard, 2020). This knowledge allows the researcher to ask insightful and relevant questions that can elicit more meaningful and authentic responses from participants. With this in mind, during the interviews, it was important balancing openness with informed inquiry which ensured that the question captures the true essence of the participants' perceptions of agriculture and the digital tools.

With this foundational understanding in place, the next segment will delve into the use of semi-structured interviews, exploring the interview guide, and how the methodology contributes to a answering the thesis statement.

4.3. Interviewguide

For the interviews, this thesis uses semi-structured interviews, outlined by Brinkmann & Tanggaard (2020). The semi-structured interview is conducted using an interview guide, which can vary in rigor and detail, depending on the interview's objectives. For this thesis, tree distinct interview guides have been developed to address the perspectives and lifeworlds of different stakeholders, necessitating specific adjustments for each group (appendix 6-9). Consequently, interview questions must be crafted to reveal the personal narratives, work, and experiences of each participant. The interview guide has been constructed based on Brinkmann and Tanggaard's (2020) guidelines from the book, organized in a table format, and distinguishes between interview and topics, as figure 2 shows:

Time	The interview will take about 30 mins.
Anonymization	You will be anonymized in this interview, and I will be the only one with working with your statements.

Theme	Interviewquestion
About the CEO and Terra Connect's Mission	- Can you tell me about your background and how you became part of Terra Connect?
	- How would you describe Terra Connect's mission and the primary goals for the company?
	- How do you see the future of digitization in agriculture, and what role does Terra Connect play in this development?
	- How has Terra Connect developed since the beginning, and which milestones have been particularly significant for the company?
Teknologi, Samarbejde, og Udfordringer	- Can you show me an example of a technology or solution that has been of great importance to your customers?
	- How does a typical day go for you as CEO of Terra Connect?
	- How do you include user feedback in the development of new solutions?

Figure 2 - excerpt from interviewguide with Terra Connect

The topics are derived from the thesis statement, and they seek to investigate the underlying perceptions and experiences related to the phenomenon, digitalization. It is imperative to differentiate between themes and interview questions due to their distinct functions. The Topics aid in our comprehension of the phenomena, procedures, and consistency issues that require investigation for this thesis. Interview questions, on the other hand, are designed to elicit certain descriptions and insights (Brinkmann & Tanggaard, 2020). Consequently, interview questions should avoid being overly academic or abstract and instead be clear and specific to be effective, so the interviewees understand them. The interview guide also includes a briefing and debriefing that explains the goal of the interview, how long it will take, and the repercussions for their involvement, including the fact that their information will be removed after a year and that they will remain anonymous.

4.4. Types of questions.

Interviews play a major role in this study's methodology for gathering qualitative data, which is based on James P. Spradley's ethnographic interviewing procedures as described in his book "The Ethnographic Interview" (1979). Spradley's method of conducting ethnographic interviews is useful for examining intricate social environments and comprehending customs and behaviors within distinct cultural situations. This section explains the structure of the interview questions, which were based on Spradley's division of questions into grand-tour and mini-tour categories.

While the interview settings in this thesis do not strictly qualify as ethnographic interviews, the methodological approach can still draw from ethnographic principles. As Spradley (1979) articulates, interviews involve two distinct but complementary processes: developing and eliciting information. Rapport, which refers to building a harmonious relationship between the interviewer and the respondent, is crucial in this context. Spradley outlines four stages of rapport-building: apprehension, exploration, cooperation, and participation. These stages are considered when conducting the interviews in this thesis, allowing for a variety of question types to be employed effectively.

Grand-tour questions, typically used in ethnographic fieldwork to discuss the locale of the setting, are adapted in this thesis to explore broader topics. For instance, a typical grand-tour question used here is, "Can you tell me about yourself and your background in agriculture?" This helps set the stage for understanding the participant's general context.

Specific grand-tour questions, which focus on recent events, include inquiries like, "Can you describe some of the challenges farmers face today when adapting to new digital technologies?".

Mini-tour questions, on the other hand, focus on specific facets of the experiences shared in response to grand-tour questions. These questions are more targeted but still flexible, allowing for deeper exploration of topics. For example, during my visit to Saltofte Gods with a farmer, a mini-tour question might be, "You mentioned using a GPS-system in the tractor during your day. Could you elaborate on that more?" This technique helps gather detailed data on specific aspects of the participant's experiences, providing precision and depth that enhance the broader descriptions elicited by grand-tour questions.

Integrating Spradley's question types into the study approach enriches and deepens the understanding of the participant's cultural context and behaviours, as specifically *Mini-tour questions* delve deeper into details, offering a nuanced understanding of the participant's experiences, and thus aligning with the phenomenological approach and case-study method.

4.5. Transcription

Transcribing interview data is an essential step in getting the data ready for analysis once it has been collected. The transcription method used in this study is based on the recommendations made by Brinkmann & Tanggaard (2020) in their work on qualitative research techniques. They state that the transcription process entails turning the spoken language of the interviews into written text, which is thereafter subjected to in-depth examination.

The transcription technique used in this thesis has been narrowly targeted. Aspects like pitch, volume, and tone-of-voice, are not taken into consideration in the transcription. Rather, the focus is exclusively on recording the significant information from the interviews. This strategy is consistent with the study's analytical goals, which place more emphasis on the information's relevance and clarity than its paralinguistic qualities. In order to simplify the analysis and concentrate more on the content that directly addresses the research issues, the transcription of tonal variations and volume was left out. This decision lessens the intricacy of the transcription process and brings the data analysis more closely in line with the study's goals and theoretical framework.

Additionally, in accordance with these suggestions, the interview transcriptions were completed soon after the interviews, resulting in improved recollection of the content. The website otranscribe.com[4] was used for the transcription; it is a manual transcription tool that enables sound to be transcribed and sped up/down. The transcriptions of the interviews are in appendixes 1-4, and are in Danish, but has been translated to English for illustration purposes.

4.6. Fieldwork

To explore the research questions of this thesis, I adopted a methodological approach informed by Sarah Pink and Jennie Morgan's concept of "short-term ethnography" (2013). This methodological choice was further enriched by the interview techniques outlined in the "ethnographic interview" from Spradley (1979), shaping the progression of my fieldwork to gain profound insights into the personal experiences and perceptions related to the digitalization of agriculture. This approach aligns with phenomenological scientific principles, aiming to understand individuals' lived experiences.

Pink and Morgan highlights that the core strength of short-term ethnography lies in its adaptability and focus on generating rich narratives within constrained timeframes. It demands openness from the researcher to unexpected developments, allowing the research to evolve with the realities encountered in the field. The active participation in the environments of the study subjects enables a nuanced exploration of how digital technologies are transforming the agricultural sector. This methodology, when combined with semi-structured interviews, yields an organized and adaptable approach to gathering varied viewpoints on agricultural digitalization from agro-tech development experts, technology providers, and farmers. With its dual approach, it is possible to examine the phenomenon in greater detail and capture not only the activities that are visible but also the underlying attitudes and meanings that are connected to digital technology.

Within the domain of ethnographic research, Pink and Morgan's "short-term ethnography" (2013) represents a crucial modification of traditional methods, addressing contemporary research challenges alongside. This approach redefines ethnographic research—traditionally a long-term, immersive engagement—as a qualitative technique that balances time constraints with the depth of insight characteristic of ethnographic study. This is particularly relevant in fields where rapid changes demand quick yet comprehensive understandings of human

[4] https://otranscribe.com/

experiences and social dynamics. This thesis endeavours aims to decode the socio-technical landscape and the societal frameworks that influence the adoption of digital tools in agriculture, addressing the broad network of stakeholders. Rather than viewing time as a limitation, Pink and Morgan (2013) advocates for using it as a basis for intensive, focused fieldwork. This strategy involves strategic immersion in the research setting to maximize every moment for collecting detailed data through various methods, including participant observation, informal interviews, and digital tools like photography and field notes.

Figure 3 - Picture from fieldwork at Saltofte Gods

As shown in the picture and addressed from my field notes, the farmer Malte, showed me how these techniques are used. Malte's use of a tractor using with precision agricultural technology—during a visit to Saltofte Gods demonstrated how onboard systems and satellite imagery maximize fertilizer delivery. This draws attention to the ways in which farming methods incorporate technology while also highlighting the socio-technical dynamics that are present in agricultural environments. Short-term ethnography thus allowed us to have

a practical conversation with the technical functionalities of these systems, and how it affects his day-to-day work. The field-notes are located in appendix 5.

4.7. Analyzing Strategy

This chapter describes the thematic analysis method guided by Nowell et al. (2017), chosen for its structured yet flexible approach to exploring qualitative data. It details each phase of the analysis, from initial data engagement to the final reporting, emphasizing the method's capacity to ensure credibility and in-depth understanding of the digital transformation in agriculture.

Following the transcription of datasets, the analysis process involves a balance between decomposition and synthesis, aiming to construct a new understanding of the material that reveals connections and orders not initially apparent. It is an intricate balance, as noted by Brinkmann & Tanggaard (2020), who describe analysis as a process that "enables one to see new connections, a new order that was not apparent from the beginning." This approach not only aligns with phenomenological methods, which integrate individual parts into a larger whole but also supports a methodological framework for managing and analysing large qualitative data sets known as a "thematic analysis" Nowell, et al also (2017) says, that it is a way for a qualitative researcher to demonstrate how the analysis was conducted and provide enough detail, so the reader is able to follow the process and thus see if it is credible.

Phase 1: Familiarizing Yourself with the Data

In the initial phase of analysis, after having conducted all the empirical research, I engaged with the data to immerse myself fully in its content, reading all of the transcriptions. The authors also suggest "It is important to be familiar with the depth and breadth of the content... which involves reading and re-reading the data, noting down initial ideas" (2017). During this phase, I used Microsoft Word to highlight significant passages and take notes that later facilitated the coding process.

Phase 2: Generating Initial Codes

I applied color-coding in Microsoft Word to categorize data segments that appeared significant, organizing them into a preliminary list of codes. Each colour represented a different potential theme, allowing for a visual grouping of related data segments. "Codes

were defined and named according to the content they capture" (Nowell et a., 2017), ensuring each code was specific and clearly linked to the underlying data.

Labeling Key
Lived Experiences and Perceptions of Digitalization
Barriers and Facilitators to Adoption
Economic and regulotory Impact
Digitalization technologies
Community

Label Name	Extracted Text
Lived Experiences and Perceptions of Digitalization	But you don't feel so great. But as I also think I have said, in addition to being a countryman, I am so privileged that I also have my hobby as my work. And I'm very fascinated by this, just like I think you are too. And of course that's also a driving force in me, and that's what we're going to start doing. And we have been doing this for many years.
Barriers and Facilitators to Adoption	What is the farmer's challenge out there, after all, is this tremendous technological development, as farmers in the 60s, or yes, maybe even older, have been involved. Yes. After all, some are all the way back from, yes, tractors and so on, but also gone from dial-up modem, and to fiber, to 5G, and automation, self-driving machines, drones, all that. And there is no doubt that there are people out there, regardless of age, who get a bit overwhelmed before, and lose track
Digitalization technologies	After all, we have farmers today who wear smartwatches and collect data out there. We have a lot of people who wear smartwatches because it detects falls if they fall over or if a cow kicks. So all that, farmers have for them. Farmers are very open to adopting things if the utility makes sense. This whole automation of data, big data, agriculture is extremely good at. People outside agriculture are not aware of how much data you have, for example, on a cow walking out on the road. Agriculture is probably one of the industries that is furthest ahead in digitizing accounting

Figure 4 - Excerpt from the color-coding of analysis

Phase 3: Searching for Themes

Following initial coding, I began sorting the different codes into potential themes, organizing related codes into meaningful clusters. Nowell et al., describe this as "collating codes into potential themes, gathering all data relevant to each potential theme" (2017). I compiled these codes and their associated data extracts into a Word table, which helped visualize and refine the thematic framework. I employed an abductive approach, where themes emerged through a synthesis of existing literature and empirical findings from the data. Although the phenomenological tradition typically favors an inductive approach, I argue that

by remaining reflective about this choice and allowing the lived experiences of the stakeholders to guide the analysis, this approach is appropriate and valid.

Phase 4: Reviewing Themes

This phase involved a critical review of the themes to ensure they were coherent, consistent, and distinct. According to Nowell et al., this entails “checking if the themes work in relation to the coded extracts and the entire data set” (2017). The themes were refined, combining or splitting them as necessary, to best represent the data set. It was important, however, to follow the phenomenological approach, and not reducing the stakeholders to a collective voice, so the themes provided in the analysis is thus a representation of the lived experiences of the stakeholders involved.

Phase 5: Defining and Naming Themes

Each theme was further refined and defined to capture the essence of the data. Nowell et al, (2017) emphasize that “themes should not be something that just summarize the data, but something about the data that captures something important about them in relation to the research question” (2017). The themes were named to reflect their conceptual content clearly and concisely.

Phase 6: Producing the Report

The final report weaves the thematic analysis into the larger narrative of the research, integrating themes with the literature reviewed and the research questions addressed. Therefore, the different interviewees are “Producing a report is not just about summarising the analysis (…) it involves interpretation of the themes, discussing their implications, and weaving analytic narrative around them” (Nowell, et al., 2017). This phase involved detailing the analysis process and findings, supported by illustrative quotes from the data.

In order to develop a conceptual framework for this thesis, it was therefore important to establish some sort of consensus overlap or conceptual overlap among different groups of participants. For example, themes such as "usability concerns" might emerge distinctly across all groups yet be articulated differently depending on the stakeholder's perspective. This means that when addressing the lived experiences of individuals into broader

societal implications, it is important to state who said it. The themes and subthemes that derived from the analysis are as following:

Lived experiences and Perceptions of digitalization

Barriers to Digital Adoption.

Subtheme: Perceived complexity and usability issues, reluctance towards change, regulatory and administrative burdens

Facilitators of Adoption.

Subtheme: Environmental and economic benefits, community and peer influence tailored solutions and support.

4.8. Introduction of respondents

The following chapter introduces the key stakeholders present in this thesis, both to gain some context but also to inform the readers how they were found. This is to show the thought-process behind the decisions that were made, but also to increase the intersubjectivity so the reader is able to follow suit and replicate the findings. The introduction and the information about them are both from interviews and the technology providers' websites as well as the correspondence through mail and phone with them.

Pseudonym	Title and location of interview	Method
Per Poul	Decision-maker, Terra Connect Decision-maker SEGES Location: At their office	Semi-structured interview
Adrian	Farmer Location: At the farm	Semi-structured interview
Malte	Farmer Saltofte Gods	Ethnographic fieldwork

Niklas	Project leader Technology Institute Location: Microsoft teams	Semi-structured interview
Jan	Decision-maker, Cordulus Location: Microsoft Teams	Semi-structured interview

Terra Connect:

Terra Connect is a commercial service provider and specialized in IT-solutions for the agricultural sector. Per, one of the decision-makers from the firm, is a former farmer himself and started Terra Connect in 2002. The article is from Techsavvy.media[5], but with accordance to their anonymization, the specific link will not be provided. Per was mentioned along with some of his statements concerning digitalization in agriculture, which is how it was possible to gain knowledge about the person, and the establishment of contact was made. The interview is a semi-structured interview that took place at their residency in Odense.
He brought along Poul, who is part of Terra Connect's Parent company, SEGES, and showcased their accounting software for branch-specific solution for farmers, and the technicalities and usability of the solution.

Adrian, farmer.

Adrian is a farmer that resides in south part of Zealand, he's a 77-year-old farmer that has been a farmer all his life, and he is still harvesting crops. The point of contact was made through this thesis' supervisor.

Malte, a farmer.

This farmer is someone that I was setup with the owner from Saltofte Gods, and the introduction with one of his farmers took place on the farms in a tractor, where he showed the functionalities John Deere tractor and operating system. The established contact was due to a google search, where the article "Implementation of precision-agriculture on Saltofte Gods" was found, and I decided to contact them based on that and set-up a day, where I could

[5] https://techsavvy.media/en/

follow Malte and talk about the precision tools in practice. The field notes of this are located in.

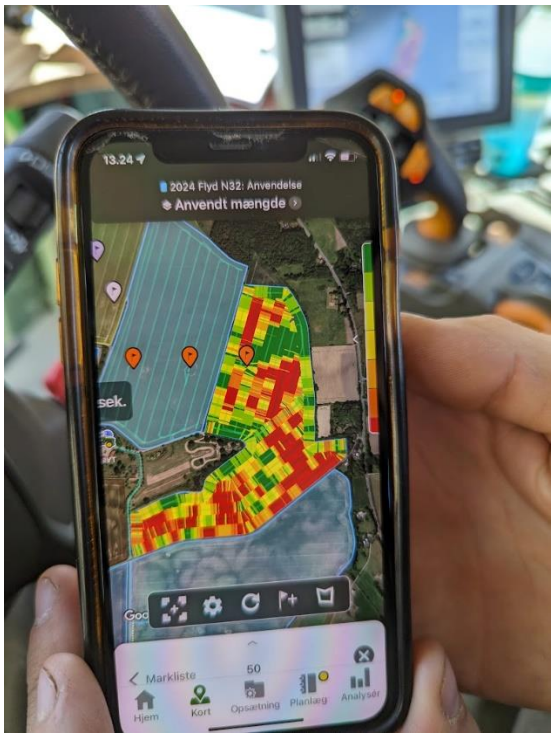

Figure 5 - Malte shows the GPS tracking from the tractor during the fieldwork.

Jan, Decision-maker at Cordulus

Cordulus is a farm weather-system that precisely tracks the weather in local areas, where the farmer can effectively reduce their costs and time. As with Per from Terra Connect, Jan was found from the same article as introduced above, and I decided to give him a call to setup a meeting.

Niklas, Project-leader at Technology Institution.

Niklas is a project-leader who has worked with digitalization of agriculture for 30 years, including IT solutions and business consulting for agriculture. He also has a degree in agricultural economics. I found him through the Technology Institution website and decided to contact him from there.

5. Theory

This chapter uses Everett M. Rogers' "Diffusion of Innovations" (2003) to create a framework for technology adoption among farmers. It will describe Rogers' model and its five stages, focusing on individual innovation-decisions, while also providing insights for broader

systems. Additionally, Icek Ajzen's Theory of Planned Behaviour (TPB) will complement Rogers' framework, highlighting how attitudes, norms, and perceived control affect farmers' adoption decisions.

5.1. Diffusion of innovation by Evert M. Rogers

The innovation-decision process consists of the following steps: an individual or other decision-making unit learns about an innovation, forms an opinion about it, decides whether to adopt or reject it, puts the new idea into practice, and then confirms the decision (Rogers, 2003). Throughout this process, there is a behaviour that essentially consists of dealing with the uncertainty when being involved in deciding a new alternative or perceived newness of an innovation. Rogers introduces the five stages from the innovation-decision process as the following:

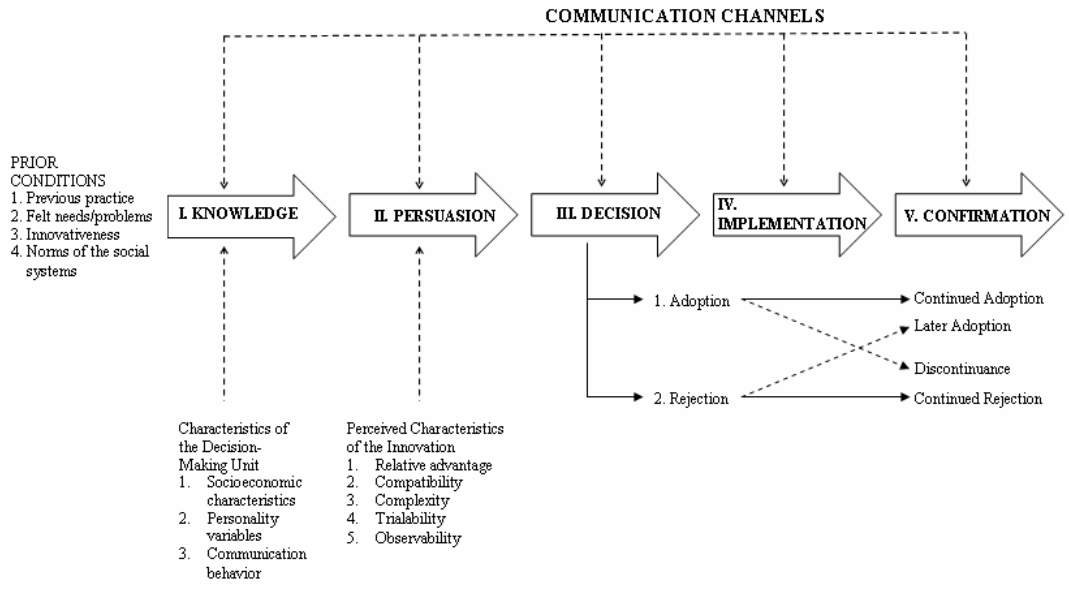

Figure 6 - Innovation-decision model from Roger's book "Diffusions of Innovations (2003)

1. Knowledge is the stage when a decision-maker (or other decision-making unit) is exposed to the existence of an innovation and gains an understanding of how it functions.
2. Persuasion is where the individual forms an approving or unapproving attitude towards the innovation.
3. Decision occurs when a decision-maker engages in activities that lead to a choice whether to adopt or reject a technology.
4. Implementation takes place when a decision-maker puts an innovation into practice.

5. Confirmation takes place when the decision-maker seeks reinforcement of an innovation-decision they have already made, but they reverse this previous decision if exposed to conflicting messages about the innovation.

According to Rogers (2003), five key attributes of an innovation significantly influence its adoption: relative advantage, complexity, compatibility, trialability, and observability. These attributes are particularly relevant when examining the adoption of digital technologies in agriculture, also known as digital farming or precision agriculture.

Relative Advantage

Relative advantage refers to the degree to which an innovation is perceived as better than the idea it supersedes, and in the context of digital farming, relative advantage can serve as a critical driver of adoption. For instance, digital technologies such as precision tools can significantly increase productivity and resource efficiency, leading to higher yields and reduced input costs.

Complexity

Complexity, or perceived ease of use, pertains to how difficult the innovation is to understand and implement. Digital farming technologies often involve sophisticated software and hardware, or an accounting system, that can be daunting for farmers who are not tech-savvy. For example, the integration of data from various sources such as drones, sensors, and satellite imagery into a coherent and actionable format can be challenging, thus impeding widespread adoption.

Compatibility

Compatibility is the degree to which an innovation fits with the existing values, past experiences, and needs of potential adopters. For digital farming technologies, compatibility issues often arise with existing machinery and infrastructure, and this may occur with a new precision technology that might not be compatible with the farmer's current tractor or planter, requiring additional investment in new equipment.

Trialability

Trialability is the extent to which an innovation can be experimented with on a limited basis. This attribute allows potential adopters to reduce uncertainty about the

innovation. In agriculture, trialability is crucial because farmers are often cautious about adopting new technologies that might disrupt their operations.

Observability

Observability is the degree to which the results of an innovation are visible to others, to which the attribute can significantly influence adoption because farmers are likely to adopt new technologies if they can see tangible benefits demonstrated by their peers. For example, if farmers do not observe clear benefits in the fields of their neighbours or peers, they may be hesitant to adopt new technologies themselves.

5.2. Izek Ajzen's Planned Theory of Behaviour

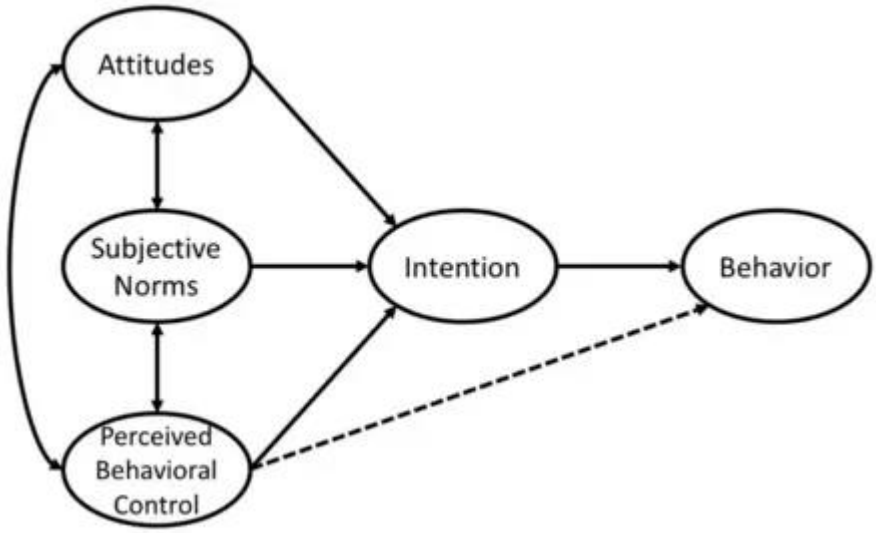

Figure 7 - Illustration of TFB by Izek Ajzen (1991)

This thesis explores the intricacies of farmers' decisions to adopt digital tools, using the Theory of Planned Behaviour (TPB) developed by Icek Ajzen (1991). TPB explains how behaviour is influenced by personal attitudes, perceived advantages like cost efficiency and productivity, social pressures, and the ease of implementation. Alongside Rogers' Diffusion of Innovation theory, TPB enriches our understanding of technology adoption in agriculture, offering a nuanced perspective on individual decision-making through a phenomenological lens.

Subjective is an individual's perception about the behaviour, which is influenced by the judgement of others, which could be in farming communities that shaped by the views

of peers, family, and advisors. Support from these influential figures can significantly strengthen normative pressures to embrace technological solutions.

Perceived behavioural control reflects the ease or difficulty anticipated in adopting new behaviours and is influenced by factors such as access to financial resources and technical support. For farmers, a high level of perceived control is likely to bolster both the intent to adopt and the actual usage of digital tools.

These intentions, closely tied to motivational factors, are pivotal in determining behaviour which ultimately leads to strong intention, coupled with a high sense of control, that leads to the adoption of digital tools, aligning with Ajzen's model (1991).

By examining these factors, as TPB suggests, we can identify specific barriers and facilitators to technology adoption based on the lived experiences of the stakeholders from the empirical data. This approach not only ensures that interventions are effectively tailored to meet farmers' needs but also enhances the overall adoption process, shedding light on the interplay between individual perceptions and collective norms.

6. Analysis

The following chapter will unravel the lived experiences and perceptions of the phenomena ‘digitalization’ among agricultural stakeholders and the impact of existing digital tools on operational efficiency and sustainability, to uncover the barriers and facilitators to digital adoption in agriculture. The thematic analysis is based on interviews among different stakeholders across the agricultural space e.g., technology providers, subject-matter experts and farmers., where the themes such as Lived experiences and perceptions of digitalization, barriers and facilitators for adoption will be uncovered. The relations between the statements will be analysed, but staying true to the phenomenological tradition also entails to not reduce the stakeholders to a common voice. To ensure coherency in the analysis some themes may overlap intentionally. Lastly, a synthesis of the analysis will be provided where theory and studies will back up the findings.

The lived experiences and perceptions of digitalisation in agriculture

This section examines the lived experiences and perceptions of digitalization among agricultural stakeholders. The analysis is grounded in a phenomenological approach and by exploring personal narratives, it aims to uncover how digital tools are integrated into agricultural practices and how these experiences shape stakeholders' perceptions. To uncover the lifeworld and perspectives of the interviewees, a few grand-tour questions based on Spradley, was asked first to build rapport, but also to gain an understanding of the lived experiences and how those may influence their meanings of digitalization. During the initial phase of the interview with Niklas, his responses towards the grand-tour questions concerning what he does and what drives him towards helping technology providers improve their solutions were as following:

"I think I am a curious person and consider myself relatively innovative when it comes to solving problems and optimizing processes. I am fascinated by how technology can improve our existing situation. Maybe it's because I grew up in the countryside and have an agricultural education (...)I've been a bit different and never been a traditional farmer who focuses on the land. I have always been fascinated by the possibilities of technology and how it can be implemented in agriculture to improve results” (Appendix 3, Translated to English)

This statement reflects Niklas' early interest in behavioral change, and understanding how and why stakeholders in agriculture might adopt new digital tools. His lived experiences of coming from an agricultural background may have influenced his curiosity

about the factors that motivate people to change their established routines and can prove to be essential for identifying the psychological and social drivers of digitalization. It suggests that his approach to digital adoption is influenced by studies of human behavior and decision-making. From the interview with Terra Connect, Per responded the following to the grand-tour questions:

> "But as I also think I have said, in addition to being a farmer, I am so privileged that I also have my hobby as my job. And I'm very fascinated by this, just like I think you are too. And of course, that's also a driving force in me, and that's what we're going to start doing. And we have been doing this for many years." (Appendix 4, Translated to English)

Likewise with Niklas, Per also comes from an agricultural background, and the quote suggests he has a personal connection to farming, viewing it both as a profession and a hobby. This highlights a passion that drives their engagement with digital tools. Per and Niklas' fascination with their profession and the longevity of their engagement underscore how personal investment and long-term experience shape their positive perception of digitalization.

Despite sharing a common agricultural heritage, they distinguish themselves by possessing distinct motivations for their respective fields of labour. Per claims that farming is both his job and his hobby, but Niklas' driver appears to be more motivated by his curiosity about behavioural changes. Correspondingly, they both seem to be deeply invested with improving the agricultural sector on a personal level. Niklas' non-traditional approach to farming, focuses on technological possibilities rather than conventional methods, and reflects a shift towards embracing digitalization and innovation. Niklas' work at the intersection of technology and agriculture suggests a holistic approach to studying digitalization:

> "I have worked on the intersection between technology and agriculture, where we examine possibilities and limitations and understand users' needs (...) what do users accept and what do they not, even if the technology is brilliant?" (Appendix 3, Translated to English).

By examining both the possibilities and limitations of new technologies and understanding user needs, Niklas aims to bridge the gap between technological potential and practical application through his work. This dual focus is also point of direction for this thesis, and like Niklas elaborates, these questions are crucial for developing digital tools that are not only innovative but also user-friendly and well-suited to the specific needs of agricultural stakeholders. Additionally, this statement underscores a central challenge in digitalization - the discrepancy between technological potential and user adoption. Even the most advanced tools

may face resistance if they do not align with user habits, preferences, or perceived needs. Niklas's personal perceptions on this issue highlight the importance of user-centered design and the need to address psychological, social, and practical barriers to adoption. Furthermore, Niklas additionally indicates a gap between access to technology and its actual use: "Many Danish farmers have modern sprayers, but they do not use them." (Appendix 3, Translated to English).

This could indicate underutilization and points to possible barriers. Addressing these barriers is essential for ensuring that investments in digital technologies translate into practical improvements in agricultural practices. Adrian, a practicing farmer, addressed the above point of underutilization with an example from his lived experience with precision agriculture, e.g., milking robots, during his own farming practices:

" I have tried them, but I think they were too cumbersome to handle. That's why I stopped and asked myself why I should continue with it" (Appendix 1, Translated to English).

Here, Adrian conveys his own personal experience with digital tools, highlighting the practical challenges he encountered. His abandoning of these tools can be attributed to their perceived complexity and inconvenience, which poses a substantial barrier to adoption. This suggests that the usability and practicality of digital technologies has something to say when determining their acceptance and subsequent use.

Reluctance towards change?

Following on Adrian's lived experience, when discussing precision farming with Niklas, he believes that precision farming is a clear case where technological efficacy does not guarantee widespread adoption. He states the following:

"I think precision farming is a good example. We can technically prove that precision spraying can reduce weeds and pests, so we can use 10% of the pesticides normally required. But not all farmers make use of it. Why is that?" (Appendix 3, Translated to English)

Despite proven benefits, such as significant reductions in pesticide use, many farmers are reluctant to adopt these methods. It is therefore essential to investigate potential underlying reasons for this reluctance. Lack of awareness, perceived complexity, insufficient training, or distrust of new technologies could be among the reasons. This distrust of new technologies and new initiatives is a factor that Adrian delves into, as he says in the following:

"It can be so frustrating that such professors can more or less slaughter an industry. They don't succeed in it, but they make it difficult for us. It's those initiatives they come up with. Then you can't emit so much, or you have to comply with so much of this and that. And it can do these and those things, and then it turns out it doesn't after all" (Appendix 1, Translated to English).

This quote provides a view of Adrian's skepticism towards the effectiveness and practical implications of new regulations and technological suggestions and highlights an issue revolving around the disconnect between theoretical solutions and their practical impact on daily operations. If the amount of "good ideas" and innovations are constantly being introduced to the farmers and they don't prove to be vital, hat may prohibit farmers from trusting new things, if they feel like they are being bombarded constantly. Additionally, this also points us towards a new facilitator for adoption, namely the need for reassurance of practical applicability, as he also says:

"And that's when new things come, new things come every year. And I say I want to see the results, (…) it could be that it was something that was relevant to me and if it's not, well then, I use what I've always used"(Appendix 1, Translated to English).

This is a sentiment that many scholars may recognize, the idea that "I'll just do what I'll always done". The question here then lies in, how do we get past that? Additionally, this reveals that the introduction of many new technologies may not always correspond with applicability and beneficial adoption for the farmers. This is due to that some of the technologies just are not ready to be put into use. Adrian does on the other hand suggest that while the present experience is difficult, he does perceive digitalization as a positive change:

"Well, mostly just that right now so many things are happening for agriculture, and companies are starting to come up with new technology that can help both the self-employed and the larger companies." (Appendix 1, Translated to English)

This recognition indicates an awareness of the potential benefits of digitalization, even amidst his current challenges and limitations, which reflects the broader future orientations and technological expectations. So, although Adrian may be more skeptical about new technologies, perhaps due to his age and technical abilities, he still recognizes that accepting new technology is a necessary thing. Poul from Terra Connect, also states:

"After all, we have farmers today who wear smartwatches and collect data out there. We have a lot of people who wear smartwatches because it detects falls if they fall over or if a cow kicks. So, all that, farmers have for them. Farmers are very open to adopting things if the utility makes sense." (Appendix 4, Translated to English).

Farmers today are incorporating wearable technologies like smartwatches and smart glasses, which collect real-time data and enhance safety by detecting falls or injuries. This openness to adopting useful digital tools reflects a positive attitude towards digitalization, provided the utility is clear. It raises the question of how the perceived value of technology influences adoption rates because this willingness to embrace technology for practical benefits shows that if digital tools can demonstrate clear advantages, farmers are likely to integrate them into their daily routines. Additionally, the usability of putting on a part of glasses doesn't require much from the farmer, but the benefits clearly outweigh the workload for them to adopt the technology. Similarly, Jan from Cordulus, notes the following concerning the adaptability and willingness to embrace new technologies and his experiences with it:

"I think farmers are extremely skilled at adapting and transforming. They have always been exposed to change. So, in many ways, they are very adaptable and accept new technology. They are actually very good at saying, 'It's okay, something needs to change here.' They have always been very important to us, very good early adopters. They do complain, of course, but they don't stop the necessary service" (Appendix 2, Translated to English)

In this statement, Jan speaks about that the adaptability is not just a response to external pressures but also a proactive approach to improving their practices, and farmers often becoming early adopters of new technologies, recognizing the long-term benefits despite initial resistance and complaints. Following these statements from Jan, to follow up on the reasons for why he thinks that farmers are so adaptable, he was asked whether the historical context might have anything to do with it. Jan provides an answer, tracing the shift from manual labor to mechanized farming and the introduction of digital tools.

"Here is a tractor and it runs on this liquid that you also must buy from us. And he was like, 'why should I get rid of the horse instead of a tractor?' There have been so many of these evolutions over time. And some of them, when you think back, can be a bit interesting. For example, the whole logic of spraying is due to a lack of labor. My uncle remembers a time when we did not spray. Okay. Where we simply weeded instead. We removed the weeds by

hand or with machines. But at some point, we could not keep up anymore. Thus, pesticides came in" (Appendix 2, Translated to English).

Innovations such as milking robots and pesticides were responses to labor shortages and economic pressures, illustrating the sector's continuous adaptation to changing circumstances, and this historical overview illuminates the current digitalization trend in agriculture, showing a shift from manual labor to mechanization and now to digital solutions. It underlines a pattern of persistent innovation in response to practical challenges. Understanding this tradition of technological adaptation helps stakeholders navigate the shift to digital tools, appreciating both the drivers and barriers of this transition. Economic pressures act as a significant catalyst for adopting new technologies aimed at enhancing productivity and reducing costs. As farmers strive to meet market demands efficiently, digital tools emerge as pivotal solutions, highlighting the symbiotic relationship between economic demands and technological advancements in agriculture.

Agriculture and sustainability

Important for this chapter concerning lived experiences, some of the stakeholders also shared their view on the relationship between agriculture, CO2 emissions and thus the motivations for digitalization.

"I remain aware that there is potential for optimization, but it is also about the environment. I fully support projects and initiatives aimed at reducing our emissions while making the country more attractive." (Appendix 3, Translated to English)

As stated, Niklas supports projects that aim to reduce emissions while enhancing the attractiveness of the country, aligns with broader goals of sustainable development and environmental protection. This perspective underscores the multifaceted impact of digital tools, not only in terms of economic efficiency but also in contributing to environmental and societal well-being. Uunderlining the broader societal implications, that digitalization is a necessity, and that there are broader motivations at hand, Niklas states the following:

"The demand comes both from the farmer, who saves on fertilizer costs, and society, who wants a reduced environmental impact. Efficiency with precision farming means that the tractors run more efficiently without unnecessary detours in the fields." (Appendix 3, Translated to English).

This shows the undeniable interconnectedness between the economic and environmental factors. Farmers seek cost savings, while society demands reduced environmental impact. Per stated the following during the interview regarding the farmers contribution to environmental and sustainability impact:

> "In any case, we work with precision farming to improve efficiency and minimize the use of chemicals, which also reduces CO2 emissions (…) the demand comes both from the farmer, who saves on fertilizer costs, and society, who wants a reduced environmental impact. Efficiency with precision farming means that the tractors run more efficiently without unnecessary detours in the fields." (Appendix 4, Translated to English)

The demand for precision agriculture therefore arises from both farmers, who benefit from cost savings, and society, which seeks reduced environmental impacts. This dual demand highlights how digitalization addresses multiple stakeholders needs. Poul notes the efficiency gains from precision farming, such as optimized tractor routes, reflecting a practical benefit that supports both economic efficiency and environmental stewardship.

Influence of media, politics, and regulation

Another topic discussed in the interviews concerned agricultural regulations and policies. In addition to regulations such as the carbon-tax and the accounting act[6] for 2024, an increase in media and political presence in agriculture has changed the requirements and demands of the farmers. These factors initially facilitate the digitalization, but the pressure may impose a negative perceived transition from the farmers. During my fieldwork visit at Saltofte Gods (Appendix 5, field notes), Malte elaborated on his thoughts, concerning the debate about carbon-tax that is flourishing on social media and other news outlets. He believes that agriculture has become the scapegoat and that this might be due to the lack of proper access to farms to cover the stories in a more positive light. Per also acknowledged this in the interview with Terra Connect and suggested that peoples negative view on agriculture potentially can serve as a barrier for collaboration surrounding sustainable agriculture.

> "Agriculture has perhaps been too reluctant to convey how they contribute to the environment. There are many misunderstandings and prejudices about agriculture, which stem from the fact that it is becoming more closed as a business and place of production,

[6] "Companies with an obligation to submit an annual report according to the Annual Accounts Act, and which use a standard digital bookkeeping system, must book digitally" from erhvervstyrelsen.dk.

which limits public access due to the risk of infection. It's about telling the story of agriculture, which is often misunderstood based on news and debates. It is important to convey the positive aspects as well." (Appendix 4, Translated to English).

Per highlights a critical communication gap: the agricultural sector's efforts toward environmental sustainability often go unnoticed by the public. This disconnects fosters misconceptions and biases, partly due to the increasing seclusion of farming operations, which restricts public visibility. He stresses the urgency of broadcasting agriculture's positive narratives to counteract the negative images often painted by media coverage and public debates. By enhancing dialogue and transparency, we can bridge the divide between agricultural practices and public awareness, fostering a more informed and supportive community. The public debate concerning the carbon-tax regulations, raises the question for this thesis, whether regulation is or could be a sustainable facilitator for adoption of technologies. Niklas states the following:

"I would say that it is an effective approach towards farmers, but it is important to be aware that what you are doing is reasonable and sensible. A measure has been introduced that requires cattle producers to register the purchase or sale of animals in the cattle database within seven days of the transaction. This has resulted in all cattle producers with access to Webdyr[7] or DMS[8], the two programs available in Denmark for such registrations, achieving full digitalization of cattle production, which is a great advantage." (Appendix 3, Translated to English).

Mandatory regulations, such as timely registration of livestock transactions, could act as both a barrier and facilitator. While they might ensure standardization and accountability, there is a possibility that they could also be perceived as burdensome. Effective implementation likely requires balancing regulatory demands with practicality and ensuring that such mandates are seen as reasonable and beneficial. However, it is possible that these regulations could be received negatively, as they might seem too intrusive to farmers. The potential for perceived overreach in digital mandates represents a possible barrier, and Niklas suggests the following.

[7] https://www.webdyr.dk/ A place where farmers register animals including purchase/sale, calving, slaughter, export, moving to/from animal shelters and common grass
[8] DMS is a program that gives an overview of cattle production.

“However, it is important to remember that this can be an aggressive intervention for the individual farmer, who must register the movement of animals from one paddock to another and at the same time update the registration with his CPR number” (Appendix 3, Translated to English).

The speculative discourse from Niklas concerning the farmers perception of regulations as “aggressive intervention” is interestingly confirmed by Adrian’s frustration in the following:

"Every single month I send accounts to my accountant, and then it is entered into the accounting system. We must do that ourselves. And you know what, I'm definitely not a computer geek. I hate it." (Appendix 1, Translated to English)

Here, Adrian discusses the burdensome requirement of documentation, expressing a strong dislike for digital tools. This segment captures the administrative challenges and personal aversion to digital tasks as significant barriers to digital adoption. It also importantly highlights how one factor can result in consecutive barriers, in this case how regulation introduces e.g., documentation which is perceived as a barrier amongst many farmers. Adrian also demonstrates another consecutive barrier resulting from regulation:

"Plus, I pay just under DKK 5,000 a year to have the accounts done." (Appendix 1, Translated to English)

Adrian’s mention of the annual cost of accounting services emphasizes the financial strain of complying with digital requirements when the farmer is not technologically inclined. This detail provides insight into the hidden costs of compliance, adding another layer of economic burden on farmers. Concerning documentation and tracking of farming operations, Jan indicates that there actually is a component of farmers expressing that they want to comply to the possible new requirements of documentation, but there is a need for a political framework on how further digitalization can help policymakers overcome the goal of reducing carbon-emissions:

"So, we have quite a few customers who ask if we can help them track the CO2 improvements they have made via our product. But we have said that it is just a big rumour, and it takes something political to ever decide how it should be done first. A lot of our customers, for example, they save trips (Appendix 2, Translated to English)

Jan acknowledges that while there is interest and demand for such capabilities, the political and regulatory landscape is not yet conducive to their widespread adoption, and this underscores the impact of regulation on the adoption of digital tools in agriculture. Without clear guidelines and support from policymakers, farmers find it difficult to invest in technologies that track and report environmental metrics. This gap between interest and implementation creates a significant hurdle that must be addressed through coordinated efforts between the agricultural sector and policymakers.

"I just know that there are many frustrations among our customers, repeatedly, this happens (...)I think my customers are hit hard by very high demands. And they seem cumbersome compared to many other professions" (Appendix 2, Translated to English)

As Jan addresses, the farmers experience significant frustration due to the requirement to document more activities, which he finds cumbersome compared to other professions. This frustration stems from the additional workload and the perceived complexity of these regulatory demands. Additionally, his lived interactions with farmers, and their experiences with additional administrative tasks shows frustration among the agricultural community. Concurrently, Niklas commented the following when discussing the political aspects of the agricultural sector:

"Yes, there are many aspects to consider. But ultimately it is a political decision. What kind of agriculture do we want? What kind of country do we want to be? And how do we get there?" (Appendix 3, Translated to English)

This statement underscores the role of policy and societal vision in shaping agricultural practices. Regulatory and economic frameworks need to be in place to achieve desired outcomes to significantly influence how digital tools are adopted. What it potentially also reveals is that there is a difference in the stakeholders view on the needed pressure from policymakers.

Main barriers and facilitators to the adoption of digital tools by different agricultural stakeholders?

This section aims to uncover the barriers and facilitators of digitalization in agriculture by exploring the lived experiences and perspectives of stakeholders. The goal is to present conceptualized ideas for potential strategies to diffuse and facilitate adoption among farmers. While it is crucial to acknowledge and validate the barriers, the primary focus is to understand

the experiences of those affected by them, offering insights into how digital tools can be more effectively integrated into agricultural practices. Niklas' lived experiences indicated awareness of the economic irrationalities or perceived necessities that drive cost decisions among farmers.

"During my studies, I was curious about what makes people do something different from what they did yesterday (...) I was fascinated by some studies that an economic institute did about why farmers buy a new fertilizer spreader when they only use it four times a year." (Appendix 3, Translated to English).

Here Niklas, points out a practical move in the direction of digitization that some businesses have made in the agricultural sector: renting tractors rather than buying them, a strategy that some technology providers companies have used to expand their operations.

"It might cost DKK 10,000 every time they use it, but if they rented one, it would only cost them DKK 1,000. What makes them buy it? What makes them switch machines? It inspired me." (Appendix 3, Translated to English)

Here, Niklas highlights a significant economic barrier: the high cost of ownership versus the lower cost of renting. His questioning of why farmers choose ownership despite the higher cost may point to deeper psychological or practical factors, such as convenience, control, and perceived reliability. Jan from Cordulus provides a weather-station technology that utilizes a rental business model and seems to have had great success with this approach, saying:

"And then we have built a piece of hardware that does not require infrastructure and is actually a rental model. So, you don't buy our hardware, but actually play with it, so to speak. And then we take 100% maintenance of it" (Appendix 2, Translated to English)

The innovative hardware and rental model offer a workable way around the financial obstacles that farmers frequently encounter when purchasing new innovations. Cordulus lowers the cost of innovative equipment and lessens the need for ongoing maintenance that requires time and knowledge of the digital tool. Farmers may be more inclined to employ digital instruments when they are inexpensive up-front and simple to maintain. It is simultaneously a way for them to try out the innovation, before committing fully.

As mentioned under lived experiences Jan identifies a critical economic issue the agricultural sector is facing, labour shortage. However, as the available workforce shrinks, the

sector is increasingly compelled to automate tasks and enhance efficiency through digital technologies. This urgent need serves as a powerful catalyst for adopting innovative solutions that help manage labour shortages while maintaining productivity, directly impacting the economic stability of agricultural operations. On one hand, the scarcity of workers necessitates the exploration of alternative solutions to maintain economic viability; on the other hand, the implementation of digital technologies requires significant upfront investments, resources, and training. Therefore, labour shortages can act as both a facilitator and barrier for integrating digital tools.

The Investment premium and custom-developed solutions

For digital technologies to be adopted widely, they must offer clear benefits that align with both supply capabilities and consumer demand. This alignment ensures that the investment in digital tools translates into tangible economic benefits for farmers. Furthermore, when it comes to facilitators and barriers for adopting digital tools in agriculture, it is a shared reality among the various stakeholders present in this thesis that custom-developed solutions are the proper standard among technology providers. An example of this, is the following statement by Per from Terra Connect:

> “Having specifically developed software or self-developed ideas will become a standard in the long run. Look at standards in other industries, they will become a benchmark for how things should be done." (Appendix 4, Translated to English)

Here Per indicates, that the way forward for the agricultural industry to flourish, is the ensure that the technologies that are being introduced, are targeted specifically to agriculture. Allowing for further interpretation of Jan's statement it can also indicate that being an early adopter can drive competitive advantages. When adopting these targeted developed technologies early, it can improve efficiency and productivity before it is standardised across the industry, achieving market edge, increased market share and profitability. The initial investment in developing and purchasing these tools can be high, but the long-term economic benefit outweighs the cost. Furthermore, Nicolai's insights add to the aforementioned complexities of technology adoption in agriculture, focusing on the dynamics between early adopters and those lagging. He notes.

> "And then there are those who become completely familiar with the systems. They are so used to using them that it is almost a part of them. But there is also a group that doesn't quite

keep up. It is a very common technological curve. This is my experience, and it fits in well with agriculture. So, if we are going to sell a solution, it must actually solve a real problem and not just be a fancy technological option." (Appendix 3, Translated to English).

This highlights a divide where technology seamlessly integrates into the routines of some, while others struggle, underscoring the necessity for solutions that address concrete problems rather than serving as mere technological enhancements. Further deepening this analysis, Nicolai touches on the psychological and social factors that influence adoption rates:

"And before we characterize it a little inhumanly as personalities, that maybe there is a connection between some of the risk takers, either become very big or go bankrupt, and therefore there are no more, then you might see some of them who are really early adaptable" (appendix 3, Translated to English).

This statement reveals the high-risk nature of early adoption, where the potential for significant success is counterbalanced by the risk of failure, creating a potent deterrent for the more risk-averse farmers.

Complexity and continuous development of digital tools vs. knowledge and proven results

But as Niklas also asks regarding why farmers don't digitalize although there are many benefits of doing so, indicates the incitement and knowledge gap regarding this:

"They stick to the old methods and do not use the new features. Why is that so? There are courses for farmers. I think it's interesting to explore what drives them. I have dealt with that." (Appendix 3, Translated to Danish)

This persistence suggests that cultural factors, habits, and trust in familiar methods play significant roles in technology adoption, and it shows Nicolai's interest in understanding these drivers which highlights the importance of addressing not only technical and economic factors but also cultural and educational aspects in promoting digitalization in agriculture. Furthermore, Niklas underscores the need for continuous updates and optimization of agricultural products.

"And the products the farmers buy must also be up to date. There is therefore potential for improvement. Should we settle for the most obvious solutions that we accept today? No, we should also optimize further through meta-optimization, which I don't see in many places." (Appendix 3, translated from English to Danish)

This statement reflects a barrier in the form of outdated technology and the lack of widespread adoption of meta-optimization practices and the facilitator here would be ongoing support and innovation to ensure that farmers have access to the latest, most effective technologies. This may also hint to the cultural barrier where farmers may be content with current solutions and hesitant to adopt new practices unless they see clear, immediate benefits. In the following quote, Niklas expands on how the ambitions and overwhelming nature of new technologies may contribute to being a significant barrier:

"I find that the ambitions are often too high for the technologies, which makes it difficult for many farmers to engage fully with all the new possibilities. There is a tendency for them to get overwhelmed and therefore not be able to take full advantage of the technology (...) Alarms and notifications go off all the time, but the real need is to understand what pace they must operate in, on a daily basis and how far they are reached. I think they often overshoot the mark with their capabilities which leads to confusion and therefore they lose the interest of many farmers." (Appendix 3, Translated to English)

Here, Niklas discusses how underutilization may result from farmers' inability to keep up with technological improvements at a quick pace. This highlights the need for scalable solutions that can be implemented gradually, enabling farmers to incorporate new technology at their own speed without feeling overwhelmed. The facilitator here would be developing intuitive, user-friendly systems that provide clear, actionable insights without overwhelming users. Another interesting barrier that has been addressed a few times during the different interviews, is the fact that farmers not only have to be an expert regarding the agricultural specialties it requires for farmers to operate with crops or livestock, which takes many years for them to become very good at. With the introduction of new technological tools, they now must change the way they have always done things. Per specifically speaks about this, and what barrier this entails:

"What is the farmer's challenge out there, after all, is this tremendous technological development that farmers in the 60s have been involved with. After all, some are all the way back from tractors and so on, but also gone from dial-up modem, and to fiber, to 5G, and automation, self-driving machines, drones, all that. And there is no doubt that there are people out there, regardless of age, who get a little carried awa, and lose track". (Appendix 4, Translated to English).

This statement here indicates the rapid pace of technological development is identified as a major challenge for farmers, especially those who have witnessed the transition from basic mechanization to advanced digital tools. This rapid change may overwhelm stakeholders regardless of age, leading to a loss of oversight and difficulty in keeping up with the many new innovations and may underscore a potential barrier of technological complexity. Adrian, being a farmer himself, expands upon the notion of seeing tangible results before adopting them:

"And when new things come, new things come every year. And then at any time I will say, 'well, I want to see the results.' And then when they come, well, it could be something that was relevant to me. And if it's not, well, I'll use what I've always used." (Appendix 1, Translated to English).

This statement was previously mentioned in relation to lived experiences and culture; it also illustrates a cautious approach revealing a barrier to adoption. Farmers prefer to rely on proven methods rather than invest in untested innovations. Additionally, a critical aspect adoption is the need for demonstrable benefits and evidence of effectiveness to facilitate the transition to digital tools. This hesitation to change reflects the broader community's cautious attitude towards innovation, influenced by the practical necessity of ensuring economic sustainability. It therefore seems to suggest, that farmers must be able to see demonstrative benefits that work in action and can prove results, and this is a point that Niklas also talk about:

"It is important that these solutions work effectively in the field, and they must be optimized to work in practical situations and not just on large screens in a control room." (Appendix 3, Translated to English)

This barrier is rooted in the disconnect between lab-tested technologies and their practical application in real-world farming conditions, and he suggests that his experience with technology providers has failed to include rigorous field testing, real-time feedback mechanisms, and ongoing support to ensure that technologies meet the practical needs of farmers.

In the interview with Poul and Per, they spoke about their operations t explained their IT solutions. In relation to the next quote, this slide was presented:

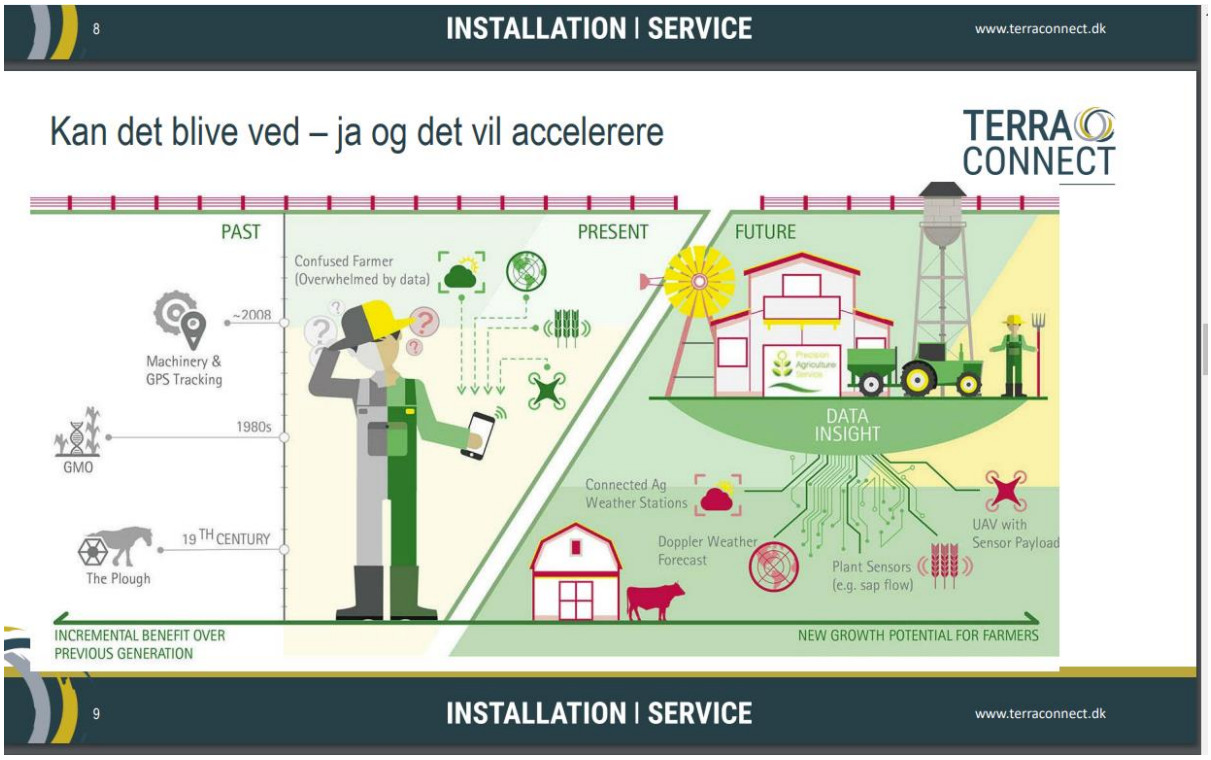

Figure 8 - Picture from the PowerPoint that was shown during interview with Terra Connect

And he said the following:

"Many farmers are standing over here on the left [points to the illustration in the middle of PowerPoint]. And what they were trained in was what they entered the profession with. There was something with hands and feet, and there was something with machinery. Now the machines may have been automated. Farmers stand a bit and are overwhelmed by the speed, overwhelmed by the data, overwhelmed by the possibilities. And then you can say, the future, it's not even the future anymore; over there [pointing to the right of the illustration], it's today" (Appendix 4, Translated to English)

This quote by Per emphasizes the aforementioned point regarding technical complexity highlighted. The speed of change and the volume of data can be overwhelming, acting as a barrier to adoption. He follows up by saying that digital technologies may seem logical and straightforward to those familiar with them, but they can appear foreign and intimidating to farmers who lack prior exposure. Per expresses that many of the farmers he meets lacks IT skills, which is a necessary component if the agricultural sector is to expand with digitalization. He says:

“It makes perfect sense to me. It is very logical, but when I visit a farmer, it can seem foreign to many of them, almost like Russian, because it is not something they have dealt with before.” (Appendix 4, Translated to English)

Niklas shares this opinion and expands upon the complication; that there is simply too much expert knowledge that requires several years of experience in addition to the traditional farming skills.

"You could argue that a farmer could just learn it all, but there's just too much to understand. It's unreasonable to expect him to be an expert in everything, especially since new technologies are constantly coming out that he needs to deal with. It makes great demands on the farmer." (Appendix 3, Translated to English)

In this intricate environment, strong support networks become crucial. Farmers need to be helped proactively by agricultural extension programs like Terra Connect, and technology providers. This entails providing training and continuous support, making material easier to understand, and arranging trial chances to lower perceived risks. This, in combination with the next quote sheds light on the farmers situation:

“After all, both you and I depend on our IT department to update the firewall, security procedures and take care of our network and mail. But the farmer is somewhat alone with it. He is his own IT manager, and that is also his responsibility. It's just not what he's trained for. He is mostly used to driving his tractor (…) But if his current system works, why switch to something new? Maybe it just doesn't seem worth spending time and resources on. He probably thinks that it is an unnecessary expense. He may not have seen the value in updating it. And if he doesn't see the value, why do it? That does not make sense.” (Appendix 3, Translated to English)

As Niklas points out, there may be a lack of dedicated IT support in agricultural settings, making it challenging for farmers to maintain and update their digital tools. Providing IT support services tailored to agriculture, simplifying technology maintenance processes, and ensuring that farmers have access to reliable technical assistance would help manage this issue. Additionally, this may point towards a key psychological barrier: resistance to change. If current systems are functional, farmers may not see the value in adopting new technologies, perceiving them as unnecessary expenses. As previously indicated by some stakeholders, it may also come down to the time constraint and prioritization challenges as significant barriers, which Per states here:

"It also has something to do with how dedicated you are. If you're a hardcore farmer and you only have 24 hours in a day, there's just something you must prioritize. And then IT becomes a time waster". (Appendix 4, Translated to English)

Time constraints and prioritization challenges become significant barriers as the education on and experience with digital tools so heavily depend on them. Farmers with demanding schedules may find it difficult to allocate time to learn and implement new digital tools. Facilitating adoption in this context requires demonstrating how digital tools can save time and increase efficiency in the long run, thus justifying the initial time investment.

Community

Another central theme portrayed by several of the stakeholders is the importance of community and loyalty in the agricultural sector. Community is a prominent facilitator and barrier for adoption of digital tools, as peer influence and visible success stories as well as word-of-mouth works as social proof. Furthermore, there is a sense of unity and support for one another, and they rely on each other's expertise when it comes to investing in new technology. In the following quote, Niklas states how the community is essential for the diffusion of digital tools:

"When they see that the spot spraying works effectively, or when they see that it is difficult to manage without it, then there is a group that follows. But there are also those who don't really adopt this until they see the sun shine." (Appendix 3, Translated to English)

As indicated by Niklas, farmers are more likely to adopt new technologies when they see their effectiveness demonstrated by others. However, a barrier remains for those who are skeptical until they witness benefits. Niklas goes to add:

"Or it is because they either go to the neighbor and ask: 'Can't you do this?' or because they are just super curious and want to challenge themselves." (Appendix 3, Translated to English).

This suggests that peer networks and individual curiosity are critical in mitigating adoption barriers, fostering an environment where new technologies are more likely to be explored and embraced.

Community and loyalty are powerful facilitators in the adoption of digital tools. The agricultural community's tight-knit nature means that once a technology is accepted by

key influencers, it is likely to be adopted more broadly. This sense of belonging and mutual support helps overcome resistance and accelerates the diffusion of innovations. By leveraging the strong community bonds within agriculture, stakeholders can promote the adoption of digital tools and ensure their successful integration into existing practices. This is also a point being brought up by Niklas, where he emphasizes the importance of trusted advisors and networks in the agricultural community, it seems that farmers heavily rely on their networks to gather information and recommendations about new technologies.

"Because you can't just sit down and understand everything in this. There's no way to do it like that. And I believe that's why it needs to be adopted well. Once it succeeds, it spreads very effectively in agriculture. There's powerful word of mouth in agriculture because you can't tackle everything on your own. It's not that you don't want to; it's just an impossible task." (Appendix 3, Translated to English)

It is conceivable that trusted advisors could become pivotal in shaping farmers' decisions to adopt digital tools, as their endorsements might carry significant weight within the community. Word of mouth and peer recommendations could potentially become powerful drivers in the agricultural sector, where farmers might increasingly look to their peers for guidance.

Can age be a barrier for adoption of the digital tools?

Niklas identifies a pattern of influence and adaptation within the community: "They see the employees as frontrunners, and then there is a group that follows (...) hey are the ones who adopt the technologies when they fit into their ecosystem." (Appendix 3, Translated to English). This highlights as above that early adopters can serve as pioneers, demonstrating the benefits and practicalities of new technologies, thereby setting a precedent that encourages wider acceptance once these innovations prove their value within existing agricultural ecosystems. In the aforementioned segments, it is highlighted how there may be an age-related aspect to adopting new technology within agriculture, and Niklas responded the following to a question that was asked concerning if this was the case:

"Yes, there's probably something to that. If you present a 60-year-old farmer with precision farming, he might say he doesn't want to learn it. It's not just a farming challenge; it's similar to a 60-year-old baker preferring to make cinnamon rolls manually rather than using a new machine. There's a certain comfort with age, and some prefer to leave it to the younger generation. However, I do see 60-year-olds embracing precision farming, often motivated by

the desire to create an attractive workplace and use modern methods." (Appendix 3, Translated to English).

The statement makes one speculate whether older farmers might be less inclined to learn and integrate new tools, preferring traditional methods. However, despite general resistance, some older farmers may adopt precision farming if motivated by the desire to create attractive workplaces and modernize their operations. This suggests that perceived benefits, such as improving workplace appeal and operational modernization, could potentially act as strong facilitators even for more resistant groups. Interestingly though, the perception of age being a factor when it comes to digitalization of agriculture and technical capabilities, is a misconception according to Poul: “We have just as bad young IT farmers with IT understanding" (Appendix 4, Translated to English)

The statement underscores that digital illiteracy is not confined to older generations; younger farmers can also struggle with IT. This barrier highlights the need for comprehensive educational initiatives that target all age groups, ensuring that digital tools are accessible and understandable to everyone in the agricultural community. It is therefore a notable statement that when constructing a conceptual framework, it needs to apply to broader populations. However, it still remains a fact, that the average age of farmers is rising, according to Danmarks Statistik (Danmarks Statistik, 2022) so if digitalization can ease up some of the resources and remove just a bit of the manual labour, it can prove to be vital for Denmark is to continue having agriculture in the same capacity that it has today.

In relation to this aspect, Adrian, himself being 77-years old, shares his lived experiences as a farmer and shows an understanding of digitalization being part of the future:

” I actually don't think they realize that this is the future. We will reach a point where our age causes things to creak and rattle. With milking robots and milking carousels, where there are no robots in the carousel, but people change positions. The moment the milk flow drops to a very low level, it shuts off and hangs up under the ceiling” (Appendix 1, Translated to English).

The mention of aging farmers struggling with the physical demands of traditional methods highlights the inevitability of adopting automated technologies, such as milking robots and carousels. Digitalization may have something to say as the average age of farmers increase, and the question then becomes, how can technology providers and decision-makers in Denmark make sure that farmers learn the proper tools to facilitate for the aging farmers?

With digitalisation comes data

Agriculture excels in the automation of data and the use of big data, often surprising those outside the industry with the extent of data collection, such as detailed tracking of individual cows. This is emphasized by Per in the following:

" This whole automation of data, big data, agriculture is extremely good at. People outside agriculture are not aware of how much data you have, for example, on a cow walking out on the road. Agriculture is probably one of the industries that is furthest ahead in digitizing accounting." (Appendix 4, Translated to English).

This segment highlights agriculture's advanced state in digitalization, particularly in data analysis. The ability to manage and analyse large datasets is a significant facilitator of precision agriculture, enabling farmers to make data-driven decisions. However, it also brings into focus the challenge of ensuring that farmers have the necessary skills and tools to interpret and utilize this data effectively. Data is renowned for being one of the biggest talk-points in society now, and many people, including farmers, may not comprehend nor have the skills to utilize them properly. The rise of AI will most likely increase the bar of capabilities required to make data-driven decisions, and that may provide further complexity for the farmers. This is where service providers, such as Terra Connect, comes in:

"And that is exactly what an advice centre like this is increasingly taking advantage of, that they generate so much data for so many farmers that they can start looking at advice in a new way. For example, ear tags with temperature, they begin to investigate correlations."
(Appendix 4, Translated to English)

The agricultural landscape has opened up possibilities for advisory centres to leverage the vast amounts of data generated to offer more informed and precise guidance to farmers. This data-driven approach represents a shift towards more scientific and evidence-based agricultural advisory services. It seems to be necessary for the adoption of digital tools, that the agricultural infrastructure has these trusted advisors and experts that can make sure the barriers can be overcome. Per says the following regarding this aspect:

"This will be a challenge for the entire industry. Many artisans and farmers have grown up fending for themselves, and there is a recognition of their own competence, where the dilemma is that all IT is becoming more and more user-friendly, which is good. On the other hand, it also becomes more complex because everything is connected" (appendix 4, Translated to English).

This segment highlights the paradox of digitalization: while it aims to simplify processes, it can also introduce new forms of dependency and complexity that require careful management. This is also highlighted here:

"Many farmers find when they buy a milking robot that they don't actually own the data – the suppliers do. And as the network expands, the foundation that owns and operates it also becomes more prominent." (Appendix 4, Translated to English).

As indicated by Per above, farmers frequently learn that the owners of the data from automated systems, such as milking robots, are the equipment suppliers rather than the farmers. The management and control of digital networks become more and more important as they grow. Data ownership is a topic that is related to more general worries about digital sovereignty and the financial effects of data ownership in agriculture.

The tailoring of digital tools

According to Per's statement, there are more and more digital tools available. While some of the tools on the market today may have been sufficient for a single farmer to handle, it is now necessary to weigh the advantages of cutting-edge technologies against the risks associated with relying too heavily on digital systems and credentials. The paradox of digitalization is highlighted in this segment: although its goal is process simplification, it can also generate new types of complexity and reliance that needs to be carefully managed. In the same interview, where Poul from SEGES also was present, some of the usability concerns were presented:

“This, Jacob, is an industry-specific solution for agriculture. Virtually everyone, there is a sea of financial systems. But this is an agricultural-specific solution developed by agriculture and today brought together by all agricultural associations. (...) It is one of the strengths to be able to speak their language, and the solution is created in a way that makes sense to them" (Appendix 4, Translated to English).

Industry-specific solutions developed by agricultural associations illustrate the importance of tailored digital tools. These solutions address unique needs and contexts, ensuring that digitalization efforts are relevant and effective for the agricultural sector. The collaboration between various stakeholders in developing these tools underscores the collective effort required to drive digital transformation in agriculture.

You cannot ask for what you don't know exists.

In the interview with Per from Terra Connect and Poul from SEGES, one of the barriers presented, is according to them, a lack of awareness among farmers that presents complications, Per says the following:

"That's what I'm saying, [Poul]. We have a challenge in that our customer group basically can't ask for something they don't know exists." (Appendix 4, Translated to English)

This highlights a fundamental barrier: lack of awareness. Farmers can't demand or adopt technologies they are unaware of. Facilitating adoption requires proactive outreach and education efforts from technology providers to introduce and explain the benefits of new digital tools, and this is a point that they are aware about where he says:

" That is why we make a point of meeting our customers. We are in a profession that requires us to drive out because we must meet them out there. Out in the field where things happen. We get feedback from the customer, maybe something that could be done smarter. We need to see what the customer is doing and why. We can't just write our way out of it or make brochures. It doesn't work that way. We have included this in the further development of the system, that we must have a best practice, and the customer must adapt. It is the most effective" (Appendix 4, Translated to English).

Here Per speaks about being a facilitator himself for an adoption process, where the emphasis is on direct in-person contact. This might involve meeting farmers in their specific contexts and ensuring that direct input is fostered. Additionally, by potentially facilitating a participatory approach of digital solutions that align more closely with real-world farming requirements and practices, acceptance could be significantly promoted. The participatory aspect is an interesting aspect for technology providers to have their innovations be adopted and diffused, but as Niklas also indicates, it seems to be detrimental for adoption processes to include stakeholders:

"There you often have to describe what their go-to-market strategy is. How do they intend to realize this product with our risk elements and such. And in collaboration with the company to formulate these sections, we tend to minimize the risk of them developing a product that does not meet the needs. We minimize this by involving farmers in the development process, or using the experience to visit and present our ideas, etc" (Appendix 3, Translated to English)

Effective go-to-market strategies might be essential for successfully deploying digital technologies in agriculture. Speculatively, close collaboration with farmers during the development process could prove crucial in ensuring that these products meet their practical needs. This approach could potentially minimize the risk of creating solutions that lack real-world applicability or usefulness.

Structural changes

"Generally, in Denmark, there is a structural development in agriculture, where the number of farmers is falling and the industry is becoming more polarized with more small and large producers, depending on the land zone and hectare size," (Appendix 3, Translated to English)

The structural changes in Danish agriculture, with a decreasing number of farmers and increasing polarization between small and large producers, present unique challenges, and opportunities. Digital tools must be adaptable to address the diverse needs of both small and large-scale operations, ensuring that all farmers can benefit from technological advancements. But creating a participatory approach for digitalization solutions may prove to be a difficult hurdle to overcome, as there are many kinds of agriculture, farmers and sizes of productions, as this statement indicates.

"The large production farms are getting bigger and own more land and more animals. It is difficult to create an industry solution that can cover both the small and large needs as well as the requirements for reporting, which I also show here". (Appendix 4, Translated to English)

The growing scale of large production farms could pose a significant challenge in developing sector-wide solutions that effectively cater to both small and large operations. This may underscore the barrier of scalability and highlight the potential need for versatile digital solutions that can be adapted to various scales and operational needs. This thesis seeks to uncover a conceptual framework based on relevant theory and empirical findings in the following chapter, to describe and explore the barriers and facilitators for the agricultural community to accept digital transformation. The emphasis on digitalization is spoken about from Poul:

"Everyone must digitalize. The small ones must digitize because their resources are limited, and they often work alone. The big ones must digitalize in order to maintain the overview and foundation". (Appendix 4, Translated to English)

As Poul states, everything needs to be digitalised. Digitalization is therefore a key step for agriculture to overcome reduced resources, labour shortage aging farmer and the growing demand of sustainable practices. The analysed lived experiences and perceptions form different stakeholder serves as a comprehensive foundation, taking barriers and facilitators into account, for policymakers and technology providers when approaching the digital transformation of agricultural practices. Niklas also points towards how digitalization and the grown demand of sustainability may hinder the production of livestock and crops, stating:

> "By reducing agricultural production, we have also reduced emissions, which has helped us meet certain obligations. There is even talk of halving our milk or sugar production. Reducing emissions helps us meet our obligations. But this also leads to redundancies, such as the 1200 slaughterhouse workers who lost their jobs." (Appendix 3, Translated to English).

This quotation captures the intricate relationship between political interference and digitization in agriculture, and while implementing digital tools and adhering to rules might aid in achieving environmental goals, they also present serious obstacles, such as increasing workloads and job losses. It seems to be critical to balance technological improvements with the economic and social impacts on the farming community.

7. Discussion

The analysis of interviews with agricultural stakeholders, including Niklas, Adrian, Jan, and other experts, reveals a multifaceted perspective and experiences on the adoption of digital tools in agriculture. In order to address the main issues of the analysis—such as the respondents' lived experiences, perceived barriers and facilitators, the effects of regulations and the economy, and the community's role in agriculture—this synthesis seeks to condense these findings into the following segment: These insights will be framed within the context of relevant theories, mainly Rogers' Diffusion of Innovations (DOI), and supplemented by The Theory of Planned Behaviour (TFB) Ajzen (1991), where lastly, a conceptual framework will be presented.

7.1. Lived Experiences and Perceptions of Digitalization

The lived experiences of agricultural stakeholders highlight a deep personal connection to farming, which significantly influences their engagement with digital tools. There is a shared person connection among the actors in this thesis, which is explicitly addressed by Per's passion for agriculture, viewing it both as a profession and a hobby, which underscores a fundamental driver of digital adoption: personal investment. The prior experience with farming and the drive for helping farmers, would according to Rogers (2003), establish technology providers such as Per, to be a Change Agent – which will be further expanded upon.

Adrian's narrative also emphasizes the challenges and frustrations that come with increased documentation and regulatory demands. Despite these challenges, his adaptability and resilience demonstrate the potential for successful integration of digital tools when they align with tangible benefits. Jan highlights the historical context of agricultural practices and how this influences current attitudes towards digitalization. Understanding the cultural and historical aspects of technology adoption is crucial, as demonstrated by his acknowledgment of the lengthy history of technological adaptation as well as the reality that farmers have experienced constant change and are accustomed to new solutions because of their sensitivity to environmental factors like weather in agriculture.

A recurrent theme is the dual demand for digitalization driven by both economic efficiency and environmental sustainability. Adrian, Niklas, and Jan highlighted how precision agriculture is frequently mentioned as a tool that addresses these needs by optimizing resource use, deals with labour shortage, increasing age population of famers and reducing environmental impact.

This dual benefit aligns with broader societal goals, reinforcing the importance of aligning digital solutions with both personal and societal values.

The personal narratives also reveal a communication gap between the agricultural sector and the public, which is addressed by Niklas, Jan and Malte. They claim that the agricultural industry's contributions to environmental sustainability are not effectively communicated, which causes misunderstandings and unfavourable opinions from the media and politicians. Addressing this gap through better communication strategies can improve public perception and support for digitalization initiatives.

7.2. Barriers to Adoption

The interviews uncover several barriers to the adoption of digital tools in agriculture. A primary barrier is the rapid pace and amount of technological change, which can overwhelm farmers, particularly those who have witnessed significant technological transitions over their careers. This is compounded by a generational gap, where older farmers may find new technologies intimidating or irrelevant to their established practices, which is highlighted by Niklas, stating, that older generations in general are less inclined to learn new practices. But as both Niklas and Per highlights, lacking IT-literacy can be observed for numerous generations.

Economic barriers also play a critical role and presents itself as one of the main barriers. The high cost of ownership versus the lower cost of renting equipment, as highlighted by Niklas, points to a deeper issue of financial accessibility. Farmers may be hesitant to invest in new technologies without clear evidence of long-term cost savings and practical benefits, and according to Reichard and Jurgens (2009), who was introduced in the literature review, the “high-initial investment” and “time consuming” are among the two most mentioned disadvantages when it comes to adoption. As highlighted in the interview with Terra Connect, digitalization and precision tools are among the technologies that can meet the demands of cost savings, but it is questionable as to whether the farmers are able to overcome the initial investment for the long-term goals.

Another significant barrier, which is highlighted by Adrian and Jan, is the complexity and perceived usability of digital tools. Farmers often face challenges in integrating new systems into their workflows, especially when these tools are seen as adding to their already heavy workload. This highlights the importance of designing user-friendly, industry-

specific (e.g., SEGES accounting system) interfaces and providing comprehensive training and support to facilitate smoother transitions. The farmer, Malte, was always emphasizing during the fieldwork visit at Saltofte Gods how the GPS- steering system in his tractor, demonstrated its high degree of user-friendliness. He said that although there were alternative technologies on the market with capabilities that seemed more advanced, they were just too hard to use because of the excessively complex technological requirements. Niklas also mentioned how "I find that the ambitions are often too high for the technologies, which makes it difficult for many farmers to engage fully with all the new possibilities." (Appendix 3, Translated to English). Further indicating that including farmers in the development process and "meeting them out on the field" (Appendix 4, Translated to English) stated by Per, is detrimental for digitalization, mirroring the must needed participatory approach among stakeholders in the industry.

Additionally, the interviews reveal that resistance to change is not confined to older generations; younger farmers can also struggle with IT literacy. Time constraints and prioritization challenges further exacerbate these issues, as farmers may not see the immediate value in investing time to learn new systems. One important issue that Drewry (2019) highlights is data safety. In a similar vein, Terra Connect highlights how important it is for farmers to understand that they do not 'own' their data. This problem persists as a significant barrier despite the desire for digitization and data-driven decision-making to optimize present processes. Per also draws attention to the fact that there is a lot of data in agriculture, and is only going to grow due to AI, which can make data analysis more demanding and limit adoption. This issue is also discussed in the article by Pivoto et al. (2019), where it is noted that commercial service providers, such as Terra Connect, exacerbate concerns among farmers; they are worried about the potential misuse of their digital data, which consequently leads farmers to exercise greater caution in their engagement with such services.

7.3. Facilitators of Adoption

Despite these barriers, several facilitators can enhance the adoption of digital tools in agriculture, and the personal commitment and long-term engagement of stakeholders like Per demonstrate that passion and curiosity can drive innovation. Peer influence and visible success stories are also powerful motivators, as stressed by Niklas, where early adopters of a technology are front-runners, and can serve as strong motivators for the community to follow

suit. Rogers (2003) would argue, that when farmers see the practical benefits of digital tools demonstrated by others, they are more likely to adopt these technologies themselves.

In-person engagement and direct feedback from farmers are critical for developing effective digital solutions, and establishing as a trusted-advisor in the community can prove to be vital if farmers are to listen to you. Adrian explicitly said, how he wouldn't listen to someone that stands out as a traditional salesperson. This approach aligns with Rogers' DOI theory, which emphasizes the importance of compatibility with existing practices and the relative advantage of innovations.

Economic incentives and support from regulatory bodies can also facilitate adoption. Providing subsidies, financial assistance, and training programs can help mitigate the initial investment costs and ease the transition for farmers. Moreover, effective communication and outreach efforts are essential for raising awareness about the benefits of digital tools and addressing misconceptions. The economic impacts of digitalization in agriculture are multifaceted. Custom-developed software and advanced digital tools can significantly enhance operational efficiency and productivity, leading to better yields and lower costs. Technologies that reduce the need for medication or optimize genetic practices can lower operational costs and improve sustainability. Early adopters of advanced technologies can gain a competitive edge in the market, potentially leading to increased market share and profitability. This can attract more investment into the sector, further driving innovation and economic growth. However, the initial investments in these technologies can be substantial, requiring careful financial planning and potential subsidies or incentives from the government.

Regulatory impacts are equally complex. As digital tools become benchmarks, regulatory bodies need to develop and enforce standards to ensure consistency, safety, and quality. Differences in regional regulations can create conflicts and challenges for farmers, highlighting the need for harmonized policies that respect local practices. Per's points about data privacy and security are also major regulatory concerns, requiring stringent measures to protect sensitive information, thus aligning with Pivoto et al (2019) study concerning that manipulating data and machines is an obstacle for adoption. But although this may seem like a barrier, the implementation of Webdyr and DMS have pushed farmers to document and register livestock production, which is a good thing, according to Jan. But it's difficult to draw a clear distinction between helpful and invasive interventions. If farmers fear that proving a new practice's

viability would make it the norm and add to their workload, they might be hesitant to take part in future projects. As Niklas notes, this worry has the potential to alienate farmers and discourage their participation:

> "However, it is important to remember that this can be an aggressive intervention for the individual farmer, who must register the movement of animals from one paddock to another and at the same time update the registration with their CPR number" (Appendix 3, Translated to English).

The integration of various digital tools and technologies in agriculture presents both opportunities and challenges. Per stated how wearable technologies like smartwatches and smart glasses enhance safety and data collection, reflecting a positive attitude towards practical digital solutions. The automation of data and the use of big data enable predictive analytics and improved decision-making, transforming traditional farming into a highly efficient operation. However, issues such as data ownership and the complexity of digital systems pose significant challenges. Concerns among data ownership is not industry-specific but is a regulatory barrier that encapsulates the whole society in this day and age. Ensuring that farmers retain control over their data, or at least understand it and can navigate the interconnected nature of digital tools is crucial. Poul from Terra Connect emphasized that industry-specific solutions, developed in collaboration with farmers, can effectively address these challenges. SEGES' accounting system provides tailored tools that meet farmers' unique needs and speak their language. As Niklas pointed out, this ensures the technology is practical and not just tested in the laboratory.

7.4. Community.

The importance of community and loyalty in the agricultural sector is highlighted by several stakeholders. Peer influence, visible success stories, and word-of-mouth provide social proof, making community both a facilitator and a barrier for adopting digital tools. Farmers rely on each other's expertise when investing in new technology.

Niklas states, "When they see that the spot spraying works effectively...then there is a group that follows. But there are also those who don't really adopt this until they see the sun shine" (Appendix 3, translated to English). This shows that seeing tangible benefits is crucial for adoption. Community and peer-reviewed technologies seems to be one of the biggest factors

for farmers to adopt new technology. Once key influencers accept a technology, it is likely to be widely adopted. Trusted advisors and networks play a crucial role, as noted by Niklas: "Because you can't just sit down and understand everything(...)Once it succeeds, it spreads very effectively in agriculture" (Appendix 3, translated to English).

8. Integrating Theoretical Perspectives

Following this synthesis, this segment will investigate how the findings can be congruous of theories presented; ROI by Rogers (2003) and Theory of Planned Behaviour by Ajzen (1991), in order to develop a conceptual framework that both policymakers, technology providers and farmers can refer to, when the growing demand of digitalization are being diffused in agriculture. As Niklas brought up a point regarding, that many firms trying to enter the field of agriculture many of them fail, so the technology providers are being examined in this thesis, offer a good deal of guidelines and best-practices that can attribute to building a conceptual framework.

A common denominator of the stakeholders interviewed, is their possession of information about the subcultural differences, the languages, beliefs, and systems that are common in the agricultural community. Rogers refers to these people as Change Agents – defined as a "communication link between a resource system with some kind of expertise and a client system" (Rogers, 2003). The essential part here is that the feedback from the client system must flow through the change agent to the change agency to appropriately adjust the intervention program to fit the changing needs of the client. Thus, having experience with agriculture or coming from a farmer background, can provide several benefits for the technology providers to cross the social and technical chasms. These technology providers are more likely to be acknowledged as leaders in the industry and can influence adoption, stemming from the importance of loyalty, community, and trusted advisors in the agricultural community.

Rogers (2003) emphasizes that once a need for change is created, the change agent must develop rapport with their clients. This can be enhanced by the agent's experience from family, community, or being a farmer themselves. Being perceived as "credible, competent, and trustworthy, and by showing empathy with the client's needs and problems. Additionally, the use of Opinion Leaders seems to be a good way for technology providers to increase their influence in the industry, as the community and the social systems are very tight knit as addressed by Jan and the change agent can thus "leverage these scarce resources and hasten the rate of diffusion of an innovation among clients" (Rogers, 2003)

Relative Advantage.

Relative advantage refers to the degree to which an innovation is perceived as better than the idea it supersedes. It basically outlines that the perceived benefits of a new technology significantly influence its adoption. Relative advantage can be expressed through various factors such as economic profitability, increased productivity, and improvements in convenience or satisfaction (2003). In the context of this thesis. relative advantage is evident when digital tools enhance productivity and efficiency, as noted by the farmers and technology providers. For instance, while digitalization offers substantial productivity gains, the high costs and time required for managing data remain significant barriers. Adrian et al. (2004) highlights these challenges in their study, stating that the high cost and time spend handling data are barriers. Rogers also explains that relative advantage can be associated with social prestige. During the fieldwork visit at Saltofte Gods, Malte amusingly explained how individuals in agricultural communities often use new innovations to convey social status, and those who don't own such digital tools are sometimes ridiculed. This shows that the social ramifications of using new technology can have a big influence on how quickly they spread throughout a community, even in addition to their financial advantages.

Complexity.

The complexity attribute refers to the degree of difficulty associated with using an innovation, which often requires extensive education or training, and that can be aligned with utilizing precision tools efficiently. Rogers (2003) compares the adoption of technology to when people in the 1980's began requiring home computers. Tech-savvy people such as hobbyists or scientists did not perceive the innovation as complex, but individuals who had no prior experience typically went through a large amount of frustration. Rogers (2003) interestingly says the following, which relates a lot to the statements of the interviews in this thesis: "The frustrated adopter was puzzled by the computer manual and got little help from salespeople, who talked confusing technical jargon. Eventually, however, most individuals joined a computers' user's club, obtained help from friends, or found other means to cope with the complexity of their home computer". This is mirroring Adrian statement, where he dislikes salespeople coming to him wanting to sell him things. Rogers finishes this by saying that the user-friendliness of these computer rose, and the rate of adoption simultaneously grew (2003). This aspect just goes to emphasize, how technologies that are being introduced, not only has to be user-friendly, as most farmers may not be familiar with that kind of technology, but also

that the change agents must be able to emphasise with the farmers and speak their "native" language in order to convey them.

"You could argue that a farmer could just learn it all, but there's just too much to understand. It's unreasonable to expect him to be an expert in everything, especially since new technologies are constantly coming out that he must deal with. It makes great demands on the farmer." (Appendix 3, Translated to English).

The burden of managing multiple, constantly evolving digital tools, as highlighted above, illustrates the overwhelming nature of technology adoption in agriculture. It is unreasonable to expect farmers to become experts in every new technology that emerges, so providing proper service and helping with setting up the proper infrastructure is important, taking off as much workload for the farmer as possible.

The farmer Malte from Saltofte Gods (Appendix 5, field notes), said during the farm visit that sometimes the farmer has to work 12 hours a day, where they won't have that much time to spend reading manuals and getting courses. He highlights how important it is for adoption, that advisors and technology firms are always available to assist and guide users when technical difficulties arise. Additionally, he adds, that there is an economic advantage in using less fertilizer, but consultants need to be involved throughout the process to ensure that the technology is used correctly.

Trialability.

Triability refers to the degree to which an innovation can be tested or experimented with on a limited basis before a full-scale adoption, and that allows potential adopters to try out the new technology and see its benefits and drawbacks without committing to a full implementation (Rogers, 2003). Jan's experience with trying and subsequently rejecting cumbersome digital tools emphasizes the need for trialability. Offering trial periods or rental models, as seen with Cordulus, allows farmers to experience the practical benefits and ease of use of new technologies without significant initial investment, while getting support for maintenance and easing the workload of the farmer. This approach not only builds trust but also demonstrates the relative advantage of digital tools in a real-world context.

"When they see that the spot spraying works effectively, or when they see that it is difficult to

manage without it, then there is a group that follows. But there are also those who don't really adopt this until they see the sun shine" (Appendix 3, Translated to English)

This statement illustrates how seeing peers successfully trial and adopt new technologies can influence other farmers to follow suit. The visibility of successful trials within the community can significantly boost the perceived credibility and reliability of new digital tools. When farmers observe their peers successfully adopting and benefiting from new technologies, they are more likely to follow suit. This peer influence, coupled with the ability to trial or rent innovations, plays a crucial role in the broader adoption of digital tools in agriculture.

Observability

Observability is defined as "the observability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption" (Rogers, 2003). It refers to the degree where the results of an innovation are visible to others, and thus are easily observed and communicated. This aspect is covered in the other attributes as well, because the community factor of the social system in agriculture plays such a big part. Jan speaks highly about the communities in agriculture and deeply emphasizes how, when you are a part of it, everyone can get accepted if they explicitly outline that "They want agriculture" (Appendix 2, Translated to English). It is important to mention, however, that this theory was made in 2003, before social media and internet was as big as it was today, so communication channels has evolved immensely, where technology providers are able to showcase the innovation a whole new way, thus increasing the observability of a product. Throughout this thesis, the emphasis on the community within the agricultural being such a prominent factor when introducing new technologies cannot be stressed enough. The farmers rely on each other's experiences and perceptions of a technology, and as Niklas said in his interview, the way for a technology provider to diffuse their innovation is through being trusted advisors (change agents according to Rogers), and follows up by stating: "The workforce shortage is expected to be addressed through digitalization (...) "In agriculture, people listen to each other because they rely on their networks to quickly gather broader insights. They are Trusted Advisors. You can't cover everything yourself, so you need trusted people in your network. If they recommend something based on their experience or others', it's worth considering. This Trusted Advisors setup for adoption is crucial" (Appendix 4, Translated to English)

Psychological attributes

The Theory of Planned Behaviour developed by Ajzen (1991), is as introduced in the theory chapter, a theoretical framework used to understand farmer's perceptions on technology adoption. The inclusion of this theory derives from the phenomenological approach of this thesis, emphasizing the significant role of farmers' experiences and perceptions with digitalization and adoption of digital tools.

In relation to the digitalization of agriculture, Ajzen (1991) would state that a farmer's intention to do something, is determined by their subjective norm, attitude, and perceived behavioural control. Adrian demonstrates how having a negative attitude regarding computers might hinder embracing new technology. He states: "And you know what, I'm absolutely not a computer nerd, I hate it."(Appendix 1, Translated to English) which implies that one may not even acquire an interested toward technology or knowledge of its operation due to a negative attitude. While a positive attitude can be seen during my visit at Saltofte Gods, when the farmer was really excited about showing me all the technicalities that the steering system, how much pesticides they were saving and how he was able to see exactly where it sprayed on the GPS (Appendix 5, field notes).

The subjective norm refers to the perceived pressure or expectation for a farmer to adopt a technology. An example of this is the carbon-tax and the media portrayal concerning this, but also the accounting law (bogføringslov) that will take place from the 1st of July 2024. Additionally, the perceived pressure may also be from the external pressure of the farmers in the community beginning to talk about new technologies among themselves and can contribute to a widespread diffusion and adoption of digital tools. The subjective norm can also stem from external expectations, such as Malte's boss's perception that mandatory CO2 documentation is inevitable, and this belief influenced his decision to invest in a new tractor with precision tools, anticipating future regulatory requirements.

Farmers' perceived behavioural control is their confidence in their capacity to accept new technology. A few characteristics and aspects that affect this confidence are the technology's trialability, complexity, and financial capacity. A farmer's capacity to make ends meet is based on their revenue and availability of government funding. This aspect also contains perceived controllability, where the user-friendliness is attributed, and the control of data is a concern for farmers. Malte specifically mentioned that the reason he was interested in utilizing the GPS

system was because he felt like he had a lot of control over it and could influence how it operated (Appendix 5).

Conceptual Framework for adoption and diffusion of digital tools in agriculture

This conceptual framework, grounded in Rogers' Innovation-Decision Model and Ajzen's Theory of Planned Behavior, elucidates the processes and factors affecting the integration of digital tools in agriculture. Drawing from interviews with agricultural stakeholders, the analysis delved into their lived experiences and perceptions, identifying both barriers and facilitators to the adoption of digital tools.

According to Imenda (2014) a conceptual framework is a synthetization of interrelated components and variables which help in solving a real-world problem, and it also serves as a springboard for further research. This pairs well with the choice of the case-study framework provided from Flyvbjerg's 5th misunderstand, as these findings are based on real-world empirical data. To create a conceptual framework, we need to draw on the findings of this thesis to provide an overview of the impacts of digital tools on operational efficiencies and sustainability. This framework will serve as a structured guide for technology providers and farmers. Additionally, it is to inform policymakers about the potential impact of policy interventions, such as the carbon tax. If such measures become a reality, digitalization will be essential in combating CO2 emissions. However, the success of these initiatives hinges on the effective diffusion and adoption of digital tools among farmers. Otherwise, it can be seen to become an "aggressive intervention for the individual farmer" (Appendix 3, Translated to English) as Niklas says, adding that "Many farmers express concern that if they participate in a project that demonstrates that certain practices are possible, it could quickly become a new rule they have to follow. This creates insecurity in the sector" (Appendix 3, Translated to English).

In order to prevent mandatory practices and documentation policies from being perceived as invasive and unanticipated regulatory burdens, the conceptual framework that follows is based on a participatory and co-creation approach among all stakeholders. The United Nations report (2014), provided in Chapter 2, has observed successful cases when this mindset has been introduced. According to Rogers (2003), this is the difference between "positive and negative incentives." He states, "Most incentives are positive in that they reward a desired behaviour

change (such as adoption of a new idea), but it is also possible to penalize an individual by imposing an unwanted penalty or by withdrawing some desiderata for not adopting an innovation." Because farmers may not participate in participatory approaches with various stakeholders and decision-makers as a result of the negative incentives, technology providers may use the following framework to diffuse their innovations and actualize many of the benefits of digitalization.

Knowledge Stage

The Knowledge Stage is the foundation in the adoption process of digital tools among farmers, which encapsulates the awareness and understanding of the technologies. Roger's DOI model is also very relevant to this stage, as it emphasises the importance of being well-versed of the availability of new technologies through the appropriate use of social networks to address issues of observability (Rogers 2003). Accordingly, Ajzen's Theory of Planned Behavior (TPB) posits that the doses of social interactions and communication within innovation networks are critical elements on the initial farmers' attitudes towards digital tools, influencing of their intension to adopt them (Ajzen, 1991).

From the interviews, it is clear that the knowledge acquisition process is crucial. For instance, Per's passion for agriculture and his role as a Change Agent helps disseminate information about digital tools to other farmers. Farm visits and demonstrations, as mentioned by stakeholders, play a significant role in spreading awareness and knowledge. Farmers like Jan emphasize the historical context and cultural dimensions, suggesting that understanding these aspects can significantly influence knowledge dissemination. This approach aligns with findings from Salimi et al. (2020), who noted that farmers' perceptions of the utility and usability of smart farming tools significantly impact adoption decisions, further emphasizing the importance of hands-on demonstrations and peer interactions. Farmers such as Jan highlight the cultural and historical context, arguing that an understanding of this can have impact on how new knowledge is received and distributed. This cultural viewpoint is important due to making new technologies more approachable and acceptable by harmonizing with the ingrained beliefs and customs of the farming community. But also understanding that digital transformation has happened throughout agriculture due to labour shortages. The study conducted by Drewry et al. (2019) (provided in chapter 2, in literature review) highlights the significance of contextualizing knowledge within historical and cultural frameworks to improve acceptance and adoption of digital technologies.

Persuasion Stage

In the persuasion stage, farmers evaluate the potential value of adopting digital tools based on a of attitudes, subjective norms, and perceived behavioural control, as they collectively influence the farmer's intention of adopting a technology. Adrian's adaptability despite challenges, and Jan's acknowledgment of the long history of technological adaptation in agriculture, illustrate how personal attitudes and experiences influence the evaluation process. Farmers assess the relative advantage, compatibility, and data safety of digital tools. As Niklas points out, the dual demand for economic efficiency and environmental sustainability influences farmers' attitudes. The subjective norm, shaped by peer influence and societal expectations, plays a crucial role, as seen in the importance of trusted advisors and community networks highlighted by the stakeholders.

At this point, the subjective norm, which is influenced by peer pressure and societal expectations, is seen as quite important. Farmers' decisions are heavily influenced by trusted advisors and community networks, which is in line with Ajzen's claim that intentions are mostly shaped by perceived social pressure. Adoption of new technologies might be facilitated or impeded by the advice and assistance provided by these reliable sources (Ajzen, 1991). Alexander et al. (2013) demonstrated how farmers' relationships with their community impact their propensity to adopt new agricultural technologies, underscoring the relevance of social networks in technological adoption.

Decision Stage

In the decision stage, farmers decide to adopt or reject digital tools based on the intentions formed in the persuasion stage. This decision is influenced by the trialability and observability of the technologies. The interviews reveal that farmers like those at Saltofte Gods find user-friendly systems like the GPS steering system for his tractor more acceptable. Trialability is critical; offering opportunities to trial digital tools without significant initial investment helps farmers make informed decisions. The visibility of successful adoption by peers, as discussed by Niklas and Jan, further reinforces positive decisions, as the possibility of observing the practical benefits of digital tools in action can significantly influence adoption rates. Rogers' model emphasizes the importance of these factors in reducing uncertainty and facilitating decision-making. Ajzen's TPB further supports this by suggesting that higher perceived behavioural control and positive social norms can lead to stronger intentions and higher likelihood of adoption.

Implementation Stage

During the implementation stage, farmers integrate digital tools into their workflows. This stage involves overcoming barriers such as complexity, usability issues, and the need for comprehensive training and support. Farmers like Adrian and those at Saltofte Gods highlight the importance of user-friendly designs and support systems, exemplified by the experience with John Deere's system exemplifies how well-designed technologies can ease the transition. Additionally, collaboration with agricultural associations ensures that tools meet the unique needs of farmers, as discussed by Poul from SEGES. Rogers' model highlights the importance of compatibility and reduced complexity in this stage, as technologies that align well with existing practices and are easy to use are more likely to be successfully implemented. Ajzen's TPB suggests that perceived behavioural control, or the farmers' confidence in their ability to use the technology effectively, is crucial, and this confidence determines how smoothly and successfully the implementation process proceeds.

Confirmation Stage

In the confirmation stage, farmers seek validation of their adoption decision through continued use and positive outcomes, which means that ongoing support and updates from technology providers are important for sustained adoption in the agricultural community.

Technology providers, like Niklas and Jan emphasizes the need for continuous improvement and adaptation of digital tools to meet evolving needs. This stage also involves addressing any emerging issues and providing ongoing training and support, and Cordulus explained how they set-up much of the infrastructure needed for their weather-service which means a lot to the farmers. Rogers' model indicates that reinforcement through continued benefits ensures long-term commitment, while Ajzen's TPB suggests that positive outcomes and sustained social support strengthen the intention to continue using the technology.

Conclusion

This thesis aimed to answer the following thesis statement:

Problem statement:

How does the digitalization of agriculture influence the adoption and diffusion of digital tools among various stakeholders, and what are the implications of these processes for the integration and effectiveness of such technologies in improving agricultural practices?

Research Questions

How does digitalization in agriculture shape the lived experiences and perceptions of different stakeholders within the agricultural community?

What are the main barriers and facilitators to the adoption of digital tools by different agricultural stakeholders?

How do economic, social, and regulatory factors impact the successful integration and effectiveness of digital technologies in agricultural practices?

The digital transformation of agriculture stands at a critical juncture, reflecting both profound opportunities and significant challenges, and this thesis, through an in-depth phenomenological and socio-technical exploration, has provided a comprehensive understanding of the factors influencing the adoption and diffusion of digital tools among agricultural stakeholders. By integrating insights from various theoretical frameworks, particularly Rogers' Diffusion of Innovations model and Ajzen's Theory of Planned Behavior, this study has constructed a conceptual framework to guide future digitalization efforts in agriculture. The findings reveal that the adoption of digital tools is heavily influenced by stakeholders' lived experiences, perceived benefits, and barriers. Some of the facilitators identified include the potential for increased efficiency, cost savings, and enhanced sustainability through precision agriculture. On the other hand, there are barriers such as high initial costs, complexity of digital tools, and data ownership concerns pose significant challenges. Thus, this thesis highlights the critical role of community, trust, and support

systems in overcoming these barriers, emphasizing the importance of collaboration between technology providers, farmers, and regulatory bodies.

Furthermore, this thesis contributes to the academic discourse by bridging the gap between theoretical propositions and practical applications in the agricultural sector, aligning with Flyvbjerg's case-study. The proposed framework not only addresses the technical aspects of digital tool implementation but also considers the socio-technical dynamics that influence stakeholders' decisions. For adoption to happen, it has to ensure that digitalization efforts are not only technologically sound but also socially acceptable and economically viable.

The implications of this research extend to policymakers, technology providers, and the agricultural community at large. For policymakers, the study underscores the need for supportive regulatory frameworks and economic incentives to facilitate digital adoption. Technology providers are encouraged to design user-friendly, adaptable solutions that cater to the diverse needs of farmers. For the agricultural community, fostering a culture of continuous learning and adaptation is crucial for leveraging the benefits of digital tools.

9. References

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