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Using Agile in Implementing Agriculture AI Projects and Farm Management

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A B S T R A C T

The world's population is in continuous increase in recent decades. This increase poses significant challenges to the agricultural and farming sector. With more mouths to feed, old farming techniques can't meet the demand. It has become increasingly crucial to adopt advanced management techniques and cutting-edge technologies to boost agricultural productivity, reduce harvesting waste and meet the growing demand for food. This necessitates a paradigm shift in managing farms and agriculture, moving from traditional methods to more innovative and efficient approaches. Two approaches that have recently gained considerable attention are Agile management and Artificial Intelligence (AI). Farmers and agricultural managers can streamline their operations, increase efficiency, and improve their decision-making capabilities by adopting Agile and AI. This paper aims to explore the unique benefits and challenges of implementing Agile management and AI technologies in the agricultural sector and provide insights into their potential to revolutionise the industry. A theoretical implementation model was created with tips and guides for implementation.

1. INTRODUCTION

Agriculture has historically been a labour-intensive field requiring human supervision for even the smallest tasks to increase productivity (Frisvold, 1994). In addition to many other skills like identifying when crops are ready to be picked (Ram and Kumar, 2020), diseases in crops (Sankaran *et al.*, 2010), and the detection of harmful insects (Pattnaik and Parvathi, 2020), are also essential to enhance productivity in agriculture (Ashokkumar, Divya Chowdary and Divya Sree, 2019). However, with the world's population projected to increase to 9.2 billion people by 2050, food production must increase by 70 per cent (Freibauer *et al.*, 2011).

As for what is unique about applying an Agile mindset in farm management, the main difference is that farming is a highly unpredictable and complex industry (Musser and Patrick, 2002). Agile methodologies can help farmers to manage this complexity by allowing them to quickly adapt to changing conditions and make decisions based on data and feedback (Bentley *et al.*, 2021). Additionally, Agile can help to improve communication and collaboration among stakeholders (Messina and

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Voloshanovskiy, 2020), which is especially important in an industry where many people are involved in the production and distribution of crops (Ali, 2015).

2. LITERATURE REVIEW

The use of technology in agriculture has been advancing in recent years. This article will present two of the most critical areas significantly impacting agriculture's advancement.

2.1 The Use of Artificial Intelligence AI

The agricultural industry in recent years witnessed rapid development driven by technological advancements, which revolutionised traditional farming practices, enabling farmers to improve their productivity and efficiency (Rimma *et al.*, 2020; Rasputina, 2022).

The agriculture industry is fragile and runs in an ambiguous environment which presents several challenges (Bhat and Jõudu, 2019; Ravago, Balisacan and Sombilla, 2019), such as climate change (MCCARL, THAYER and JONES, 2016), soil degradation (Lal, 2015), water scarcity (Dinar, Tieu and Huynh, 2019), labour shortage (White, 2012), and food safety concerns (Byrd-Bredbenner *et al.*, 2015). These challenges can significantly affect crop yields, livestock health, farm profitability, and public health (Kang, Khan and Ma, 2009). Advanced management techniques, such as Agile methodologies and technologies like AI, can be applied to farm management to address these challenges (Wisitpongphan and Khampachua, 2016; Arvanitis and Symeonaki, 2020; Mesaros, Rusu and Mesaros, 2022). The aim is to have more flexibility and help farmers respond quickly to changes in weather and market demand which enhances the efficiency and productivity of the agriculture industry.

Artificial Intelligence (AI) has emerged as a solution to this challenge. AI has been incorporated into agriculture to tackle problems related to in-field monitoring, pests, soil diagnosis, predictive analytics, and autonomous robots (Eli-Chukwu, 2019).

The key points are:

- AI is being used for in-field monitoring with computer vision. Computer vision is being used to monitor the health and progress of crops in the field (Zhu *et al.*, 2016). Pests are a major issue in agriculture as they cause damage to crops and can transmit bacterial, viral, or fungal infections to a crop, resulting in significant losses (OERKE, 2006; Savary *et al.*, 2019). Using computer vision through drones, farmers can identify harmful pests in crops, and the drone can spray the crop with pesticides (Chen *et al.*, 2021). Computer vision is also used to check crop readiness and livestock health (Ma *et al.*, 2016).
- AI is used for soil diagnosis (Inazumi *et al.*, 2020). researchers have developed algorithms that can identify the strength and wellness of soil with an AISQI grading system (Andrade *et al.*, 2021), reducing the chances of growing underdeveloped crops while optimising the potential for healthy crop production (Paustian *et al.*, 2016; D N and Choudhary, 2021).
- Predictive analytics is another application of AI in agriculture (Ramanathan, L and Venusamy, 2022). With the help of data-driven agriculture, farmers can utilise precision farming, which detects and identifies crops that require water or pesticides and provides it only to the plants that need it (Kocian and Incrocci, 2020). This method substantially reduces the cost and wastage of water and pesticides. Big data can be used as actionable insights, helping farmers make decisions to improve sustainability and efficiency, reduce costs, and increase profitability. This consists of collecting data from soil sensors, wireless sensors, and other external sources, such as local weather data (Ivanov, Bhargava and Donnelly, 2015).
- Autonomous robots are one of AI's major applications in agriculture. They help increase productivity while allowing farmers to focus on more complex tasks (Rahmadian and Widyartono, 2020). Autonomous robots can perform various tasks, such as planting, fertilising, weeding, and harvesting crops (Bogue, 2016; Sowjanya *et al.*, 2017). They can also provide real-time data on soil moisture, nutrient levels, and crop growth (Piper *et al.*, 2015).

Overall, AI has the potential to revolutionise the agricultural industry and address the challenges posed by the growing global population.

2.2 Using Agile to Manage AI Solutions:

AI project applications are usually made through data management (Megeto *et al.*, 2020; Williamson *et al.*, 2021). AI is already fast-growing, and it is disrupting Agile itself in a positive way (Gupta, 2022). By automating repetitive, high-volume tasks, AI can help project managers and team members by enabling project analytics for estimation and risk prediction, offering practical recommendations, and making decisions (Dam *et al.*, 2019). Agile management principles and methodologies can be applied to developing and implementing AI solutions in agriculture.

On the other hand, applying Agile in AI projects can be challenging, thinking about how AI projects need to be delivered in pieces and the ability to develop separate functions or slices of the software. However, ChatGPT, an open AI model released in November with the potential to revolutionise technology use, has been released steadily through improvement iterations, using collected feedback from social media. It is still a continuous improvement project (Guo *et al.*, 2023).

Agile management is an iterative and collaborative approach to project management that emphasises adaptability, flexibility, and customer satisfaction (Meyer, 2014). When applied to the development of AI solutions in agriculture, Agile management can help ensure that the solutions are responsive to the specific needs and challenges of farmers, that they are developed and implemented efficiently and cost-effectively, and that they deliver measurable benefits to the end-users (Dong, Dacre and Bailey, 2021).

For instance, Agile management can be applied to developing AI-based applications for precision farming (Linaza *et al.*, 2021). By working in small and cross-functional teams, with a focus on delivering incremental value and continuous improvement, developers can ensure that the applications are tailored to the needs of farmers, that they are easy to use and integrate with existing farming practices, and that they provide accurate and timely information to support decision-making (Nicholls, Lewis and Eschenbach, 2015).

Furthermore, Agile management can also be applied to implementing AI projects, using a feedback-driven and collaborative approach. Farmers can work closely with developers to identify the requirements and resolve any faced issues. (Franky, 2011) also indicated that by doing this the solutions can be optimised, ensuring they are aligned with their evolving needs and priorities

2.3 The complexity and high unpredictability of farming

Farming is subject to numerous variables and external factors beyond farmers' control. For example, weather patterns (Karki, Burton and Mackey, 2020), pests (Paredes, Rosenheim and Karp, 2022), disease outbreaks (Cavallo, 2021), soil quality (Alam, 2011), market demand (Thornton, 2010) and changing production technologies (Kingwell, 2011). These factors can significantly impact crop yields and profitability, are often difficult to predict and can vary greatly from year to year and from one location to another. In Addition, Farming involves a wide range of tasks and activities, from planting and harvesting to marketing and sales, each with its challenges and complexities (Dockès *et al.*, 2019). These factors contribute to the unpredictability and complexity of farming as an industry and urge the need to adopt better management strategies like Agile to deal with uncertainty.

2.4 The Use of Agile in Farm Management

Agile management is a methodology that has proved effective and can be applied in various industries, including agriculture (Wisitpongphan and Khampachua, 2016). Here are a few examples of how Agile can be applied in farm management:

The agile methodology emphasises **iterative planning** (Larman, 2003), which can be applied to crop management (Debaeke *et al.*, 2009). For example, a farmer can plan for a crop's growth and success early and adjust plans based on progress and data collected through various methods such as sensors, drones, and data analytics.

Scrum Methodology works on aligning the team and removing obstacles for them, every day the team meet up in the morning to answer three basic questions that truck the work for each developer; these questions are:

1. What did you do since the last scrum meeting?
2. Do you have any roadblocks?
3. What will be your subsequent step/work until the next meeting?

A sprint is a significant part of this method; it is organised by selecting prioritised tasks from the backlog and moving it to an arranged sprint. The team members will pick the tasks from the backlog according to their perspective, instead of the traditional way where a manager will assign the tasks for individuals; a pull system is used here, which empowers teams and improves their commitments to the given estimation of each task. The team agrees to finalise selected features or tasks within the sprint iteration, usually two weeks (Srivastava, Bhardwaj and Saraswat, 2017).

This Agile framework emphasising teamwork, collaboration, and a structured approach to completing projects, and it can be applied to farm management (Khudadad et al., 2014). For example, when a farmer coordinates a team to prepare land for planting or harvesting, they can work in sprints or iterations, with each team member contributing to the project's overall success.

Continuous Improvement: Agile software development is an iterative approach that emphasises collaboration between cross-functional teams and continuous improvement (Thomas, 2006a). It is a fundamental part of Agile (Denning, 2013; Stocker, 2018), which can be applied in farm management (Wisitpongphan and Khampachua, 2016). For example, a farmer can track crop growth, analyse the data to identify improvement areas, and then apply changes to improve crop quality, quantity, and sustainability.

Flexibility is another Agile core principle (Motschnig-Pitrik, 2015). It can be applied in farm management by allowing farmers to respond quickly to changes in weather patterns, pest infestations, and other unexpected events (Nozières, Moulin and Dedieu, 2011). For example, if a sudden storm damages a crop, the farmer can adjust plans and implement changes to salvage as much of the crop as possible.

Collaboration is a key component of Agile management (Ram* and Vijayakumar, 2019). team collaboration and uncertainty-focused approaches such as Agile (Perminova, Gustafsson and Wikström, 2008) can be applied in various ways in farm management, such as working with other farmers to share resources, expertise, and knowledge (Mendoza *et al.*, 2011). Collaboration is meant with all stakeholders, not only internal team members. Other stakeholders in the agriculture industry should also be considered, such as distributors, processors, and retailers. This ensures optimising the whole process from the moment seeds are in the grounds to the delivery of crops to market promptly and efficiently (Lutz, Smetschka and Grima, 2017).

In conclusion, Agile principles can be applied in various ways in farm management, from planning to execution to continuous improvement and collaboration.

3 METHODOLOGY

To conduct this research, comprehensive literature was reviewed. Literature topics included using the latest management and advanced farm and agriculture technologies. As a result, a model for applying Agile methodology in agriculture was proposed to manage Agile implementation at the farms. The possibility of using Agile for managing AI projects was also proposed.

The literature review follows a systematic approach. That includes three major steps: identifying relevant studies, critically evaluating their quality, and evaluating the results.

The identification of relevant literature is carried out through an extensive search of various electronic databases such as Web of Science, Scopus, and Google Scholar. A set of keywords is used, including "agile," "farm management," "precision agriculture," "farm management information system," and "digital business ecosystem."

Then studies were selected based on predetermined inclusion and exclusion criteria. On the one hand, Inclusion criteria are papers that focus on utilising agile methodology, farm management information systems, precision agriculture, and related technologies in agriculture. On the other hand, Exclusion criteria are papers not written in English or not peer-reviewed.

After selecting the literature, the quality of the papers is critically evaluated using a checklist adapted from previous studies from 1987 to 2023, as shown in the figure. The checklist includes criteria such as the research question, methodology, data collection, analysis, and contribution to the literature. The selected literature is categorised into high-quality and low-quality papers based on the quality assessment.

The final step in the systematic literature review is synthesising the literature. In this step, the themes and findings of the high-quality papers are identified, analysed, and integrated to propose a model for applying the Agile methodology in agriculture and farm management. The model will comprise steps that will guide farmers and agricultural businesses in implementing Agile in their farm management information systems and precision agriculture practices.

In summary, this study employs a systematic literature review approach to propose a model for applying Agile in agriculture and farm management. The study will identify relevant literature, select the literature based on predetermined criteria, evaluate the quality of the literature, and synthesise the high-quality literature to propose a model.

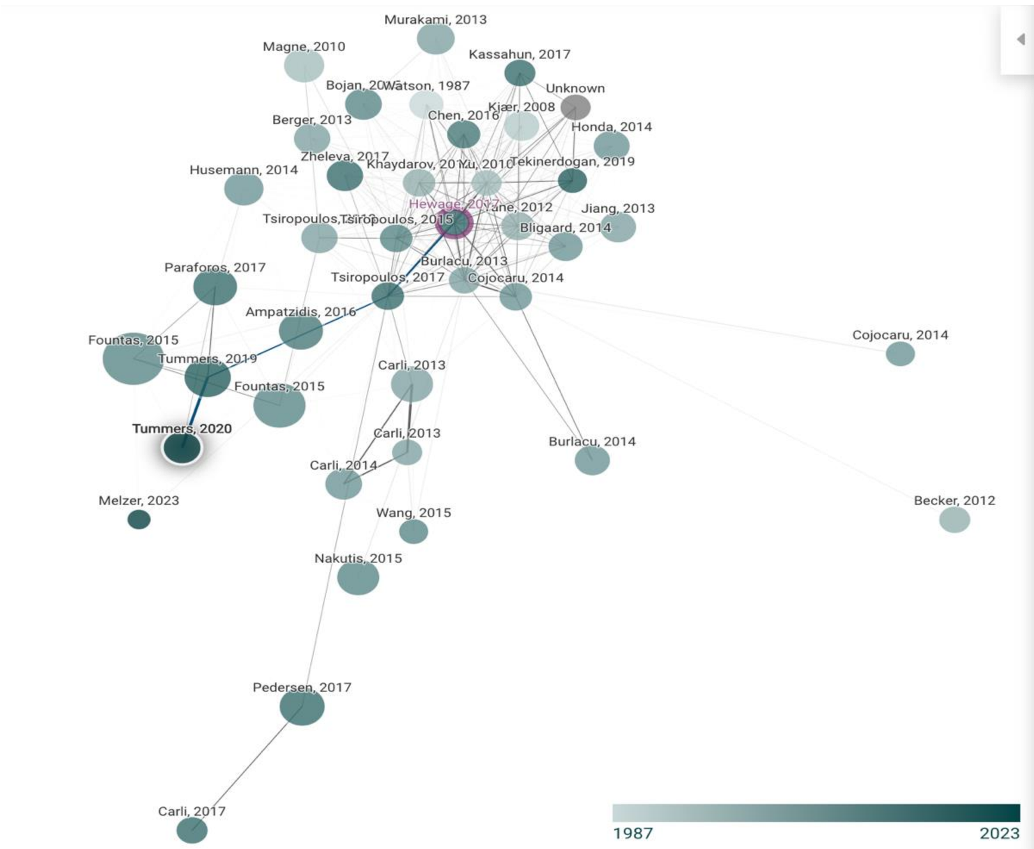

Figure 1: Systematic literature review graph (Own source)

4 DISCUSSION AND RESULTS

To our knowledge, no specific research suggests a step-by-step model for adopting Agile in farm management. However, after reviewing the literature, here are some general guidelines and a suggested model that could be applied directly to farms.

4.1 Agile farm Management Five points guidance

1. Start small and gradually scale up: It's essential to begin by implementing Agile methodologies on a small scale and gradually expanding them to other farm areas. This allows the farmers to understand the benefits and challenges of Agile and make adjustments as needed.
2. Identify areas for improvement: The first step in adopting Agile is identifying the areas in farm management that need improvement. This can vary according to the farm specific existing processes, but it could include farming farm internal processes like crop planning or external processes like inventory management.
3. Involve all stakeholders: It's crucial to involve all people influencing the process in the Agile mindset. This can include farmers, farmworkers, and customers. As a result, this ensures that everyone contributes to the process and is committed to process success.
4. Utilise Agile tools and techniques: Farmers can use scrum daily stand-up, sprint planning, and retrospective meetings to improve communication, collaboration, and efficiency.
5. Getting feedback: Farmers should measure progress regularly and use metrics to track performance. The aim is to identify improvement areas and adjust when possible.

4.2 Agile Farm Management Seven-step model

Here's a detailed step-by-step model to apply Agile in farm management:

1. Farm management goals: The first step is identifying a list of goals and tasks. Each task might include a list of crops to grow, what equipment is required, and the expected achievements. The goals should be SMART goals which are clear, specific, achievable and time measured. The entire team should be aligned on these goals.
2. Backlog of tasks: Once the goals have been identified, create a backlog with all the tasks ranked according to priority in a later step. The backlog should include all functions required to achieve the farm management goals, such as soil testing, equipment maintenance, and irrigation scheduling. Sub-tasks can be created later for selected implementation tasks to prevent excessive planning, which is considered a waste of time in Agile.
3. Prioritising tasks: the backlog of tasks is ranked based on their importance, value, difficulties, and urgency. Agile is a value-driven method focusing on delivered value instead of how the task is done. This will help maximise the value, focus on the most critical tasks, and ensure they are completed on time.
4. Break down tasks into sprints: After prioritising the backlog, break down the tasks into sprints. A sprint is a short, fixed period of time, usually 2-4 weeks, during which a specific set of tasks is completed. Each sprint should have a specific goal and deliverable.
5. Hold a sprint planning meeting: At the start of each sprint, a meeting is planned with the entire farm management team. In this meeting the team will review the backlog, poker estimate the effort needed for each task in story points and select a set of tasks to be in the sprint. At the end of the meeting, the sprint goal and deliverables should be clearly defined, and all questions about the tasks should be answered.
6. Hold daily stand-up meetings: This meeting aims to review progress, discuss roadblocks, and adjust plans if necessary. The meetings are usually short and focused on reporting the progress and presenting roadblocks.

7. Review progress and adapt: After every sprint, the team gathers for a sprint review meeting to assess how much progress has been made. Stakeholders are invited, and completed work is presented to collect their feedback. Continuous feedback helps adjust future tasks and prioritise tasks in the backlog accordingly.

Incorporating Agile methodology into farm management practices enables greater flexibility and responsiveness. The primary objective is to reduce waste and improve crops' overall quality and yield.

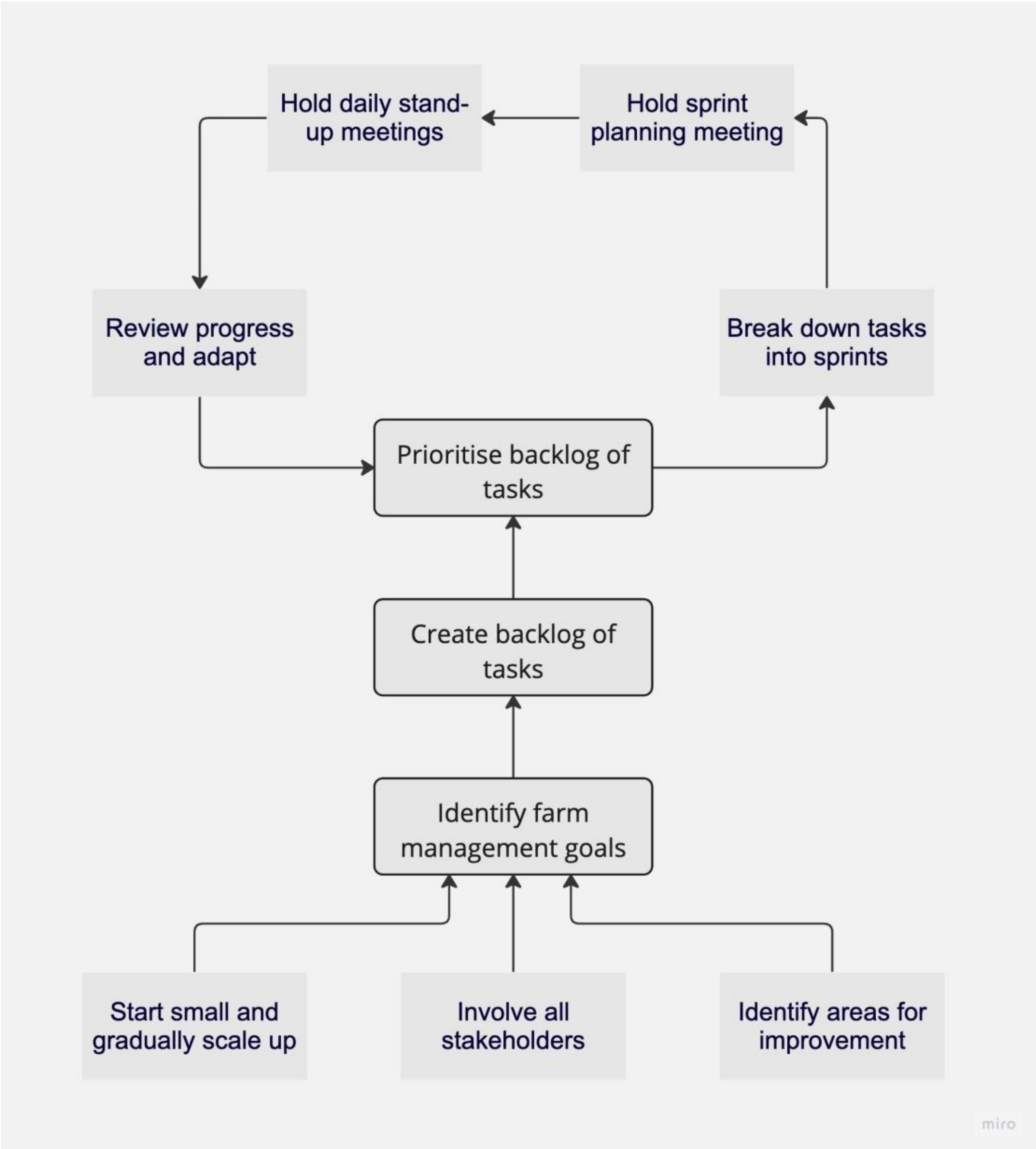

Figure 2. Agile Farm Management model (Own source)

5 CONCLUSION

Many challenges are presented and discussed by scientists in the agriculture and farming sector. Most of the challenges are provoked by the global population's rapid increase in recent decades. Artificial Intelligence (AI) has gained considerable attention after last year's latest breakthrough. At the same time, a few scientists have tested Agile to see whether it can boost agricultural flexibility, reduce waste, and meet the growing demand for food. This paper explores the unique benefits and challenges of implementing these two areas in the agricultural sector and provides insights into their potential to revolutionise the industry. A theoretical implementation model was proposed, which can serve as guidance with critical tips for succeeding in the transition.

The study used a systematic literature review approach to back up the theory behind the Agile implementation model in farm management. It was argued that the agriculture industry is fragile and runs in an ambiguous environment that presents several challenges, such as climate change, soil degradation, water scarcity, and food safety concerns. While Agile was first introduced in the software development industry to overcome the ambiguity presented in that industry, it seems logically able to benefit the agriculture sector, which was not a foreigner for applying new advanced management techniques and technologies like AI. In addition to addressing these challenges, Agile can also enhance efficiency, productivity, flexibility, and responsiveness. The article suggests that Agile then leads to higher profitability by allowing farmers to respond quickly to weather patterns and market demand changes. It also proposes several ways to apply Agile principles in farm management. These principles are iterative planning, scrum methodology, continuous improvement, flexibility, and collaboration.

After reviewing previous literature on Agile implantation in agriculture, this article highlights the areas which other researchers did not fully cover or missed in their literature review. More research is needed on the following areas:

1. Implementation challenges: researchers discussed the potential benefits of adopting agile in farm management, but there wasn't any focus on the challenges. Implementing Agile can require significant changes to existing processes to become more flexible. However, resistance to change might present. Training and support for farm managers and workers might be required to overcome this challenge.
2. Technical infrastructure: Implementing agile methodologies often requires a robust technical foundation for tracking data and analytics. Previous literature may not have fully addressed the technical requirements for adopting agile methodologies in farm management, particularly for small-scale farms with limited resources.
3. Cultural barriers: These articles may not fully address the cultural barriers within the farming community, particularly among older or more traditional farmers who may resist change. Agile methodologies may require significant cultural shifts and be more challenging in specific farming communities.
4. Environmental factors: While these articles discuss the potential benefits of agile methodologies for responding to changes in weather and crop conditions, they may not fully address the potential environmental impacts of these methodologies. For example, increased use of digital tools and data collection may have negative environmental impacts, such as increased energy consumption and e-waste.

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