

## Article

# Conditions for a Convergence between Digital Platforms and Sustainability in Agriculture

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**Abstract:** Recent research has embraced the idea that digitalization is becoming a significant factor in addressing sustainability challenges. Digital platforms are becoming integral to this dynamic, opening a vast spectrum of possibilities that remain insufficiently explored. Alongside the growing expansion of digital platform initiatives, agriculture faces major sustainability concerns that constantly reshape the organizational patterns of farmers, consumers, and institutions. Despite recent research interest in the field of digital platforms, few studies highlight their potential for fostering sustainability. This article aimed to explore the conditions digital platforms need to fulfill to enhance sustainability in the agricultural realm. First, through a literature review on digital platforms and first-hand observations, a categorization of digital platforms in agriculture is sketched and their potential outcomes are explored within the theoretical framework of digital sustainability. Then, based on data gathered from semi-structured interviews with an expert panel, we provide insightful contributions on the convergence between digital platforms and sustainability. Our findings suggest that a comprehensive and holistic approach is necessary to unlock the potential of digital platforms in promoting sustainability in agriculture. By meeting the key conditions identified in this article, digital platforms can serve as powerful tools for driving sustainability in this critical sector. The theoretical implications of our research can contribute to advancing academic inquiry in the field of digital platforms and sustainability, while the practical implications can serve as valuable guidance for the development of digital platform initiatives that support sustainability pillars in agriculture.

**Keywords:** digitalization; digital platforms; sustainability; digital sustainability; agriculture



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## 1. Introduction

Digital platforms have emerged as a global phenomenon that challenges the foundations of existing businesses and introduces new production, consumption, and distribution patterns into the modern economy [1,2]. Similarly, the spread of digital platforms over the past few years continues to reshape the way farmers, institutional structures, entrepreneurs, and consumers are organized in the agricultural landscape [3].

As digital platform initiatives continue to expand, agriculture is also facing major challenges related to climate change and land degradation. Being an integral part of the United Nations's Sustainable Development Goals (SDGs); including SDG 2: Zero Hunger, SDG 12: Responsible Consumption and Production, SDG 13: Climate Action, and SDG 15: Life and Land [4], ensuring food safety and efficiency of practices while strengthening synergies between stakeholders involved in the value chain are central concerns for agriculture [5,6]. In this context, the agricultural sector is undergoing two fundamental transformations: the rise of digital platforms and sustainability urgency.

Digitalization has unleashed a new era of agricultural transformation with digital platforms emerging as an important part of this dynamic, thus opening a wide range of opportunities to address sustainability issues that remain insufficiently explored. Digitalization refers to the process by which digital technologies provide new opportunities

for value creation [7]. Digitization has been embraced as an instrument for tackling sustainability concerns [4–7], and there are several indicators that the sustainability approach will play a key role in the development of the digital era [5]. Research investigating this intersection tends to either address a specific aspect of digitalization or a single pillar of sustainability rather than providing an integrated view of digitalization and sustainability on a multidimensional level: economic, ecological, and social [8]. Despite the increasing correlation between the two phenomena, it has been acknowledged that a positive intersection is not necessarily implied [9]. Therefore, it is important to maintain a clear overview of underestimated risks and disadvantages of digitalization to offset any potential negative impact on sustainability objectives in the long term [10].

Recent literature reveals a significant gap concerning the nexus between digitalization and sustainability in agriculture. The potential of this convergence is underscored by a limited body of research [5,6,11–13], and to date, only a few studies have been conducted on digital platforms and their potential to drive sustainability in agriculture [3,14–16]. Based on in-depth interviews with an expert panel, this article aimed to explore the conditions for convergence between digital platforms and sustainability and highlight the specific features of the agricultural landscape. By investigating how the interplay between digital platforms and sustainability is shaped, we strive to contribute to the emerging multidisciplinary discourse on how these two megatrends are driving fundamental transitions in agriculture.

## 2. Theoretical Framework

### 2.1. Digital Platforms in Agriculture



Research on digital platforms is an interdisciplinary and diverse area of academic inquiry. Scholars from different disciplines have varying perspectives on digital platforms and on how they enable value creation [1]. In the field of information systems, a socio-technical approach to studying digital platforms is widely adopted [17], while a market-oriented perspective tends to be more popular in the economic discipline [18,19], and technology management literature largely embraces a technical perspective [20]. In recent literature, the scope of the sharing economy is emerging as one of the most prominent trends [21] in the study of digital platforms [22–25], and the ecosystem-specific approach was highlighted as a fruitful basis for spurring innovation [26] and developing new theories in the field [1,2]. This diversity of perspectives broadens the scope of academic research on digital platforms. However, without an interdisciplinary dialogue, several aspects may remain beyond our common grasp [21] and hinder digital platforms' potential to proactively address sustainability issues [17].

This article describes a digital platform as a technology-based business model that generates value for its users by employing digital communication channels. It's an ecosystem that allows distributed individuals and networks to interact, share information, and access a wide range of resources in a simplified manner [1]. As such, digital platforms enable different actors to interact in real time [27]. Another feature of a digital platform is its intangibility, which implies the possibility of reusing the data collected in various contexts over the platform's lifespan [28].

Digital platforms continue to spread across the agricultural sector, yet the scientific literature covering this expansion remains limited. As they continue to cross the boundaries of existing institutions and blur geographical lines, they present a challenging area of research. This challenge stems from the lack of a common conceptual definition and understanding of their underlying features [1,21], and the lack of clarity regarding the different categories of digital platforms, particularly in agriculture.

Digital platforms span the entire value chain in agriculture (Table 1). The “Upstream level” includes platforms dedicated to sourcing and funding. This first category includes (1) marketplaces specialized in sourcing agricultural commodities via online platforms, (2) crowdfunding platforms for funding projects that contribute to the sustainable transition of agriculture, (3) jobbing platforms for recruiting farmers to perform short-term tasks, and (4) peer-to-peer platforms that enable transactions among farmers.

**Table 1.** Digital platforms in agriculture \*.

Upstream level	Resources and funding		
 Intermediate level 	Marketplaces e.g., Agriconomie, Farmitoo	Crowdfunding e.g., Miimosa, AgriLend  Peer-to-peer platforms e.g., votremachine.com	Jobbing e.g., AgriKolis, JobAgri
	Exchange and cooperation		
	Knowledge-sharing e.g., CampusAgri by McDonald's France, TriplePerformance, RexAgri	Exchange and pooling e.g., myCumaLink, echangeparcelle.fr	Data valuation e.g., FarmLeap
Downstream level	Short channel distribution		
	Short-line distribution e.g., LaRucheQuiDitOui!, ViteMonMarché, AgriLocal	Recycling unsold products e.g., Hors Normes	

Source: the authors. \* This categorization is based on a selection of digital platforms involving farmers as direct participants in the ecosystem. The authors established this categorization based on direct infield observations and interactions with professionals in the agricultural ecosystem in France.

The “Intermediate level” encompasses exchange and cooperation platforms, namely (1) Knowledge-sharing platforms designed to enable the exchange of relevant information and experiences among the various stakeholders involved in the network, (2) Exchange and Pooling platforms dedicated to sharing and optimizing the use of available resources, and (3) Data evaluation platforms for coordinating, networking, and comparing technical, economic, and environmental data.

The “Downstream level” includes (1) digital platforms for short-line distribution that enhance farm-to-fork approaches and aim to accelerate the transition to sustainable food systems and (2) digital platforms for recycling unsold products to reduce food waste.

## 2.2. The Nascent Concept of Digital Sustainability Applied to Agriculture

Digitalization and sustainability are major trends that continuously reshape the economy and society [7,8,29], requiring significant shifts and collaborative efforts to seize their innovative potential [29,30]. In a recent review conducted by Del Río Castro et al. (2021) [7] on digitalization to achieve the United Nations’ Sustainable Development Goals (SDGs), the authors highlighted that the intangible nature of digital solutions enables wider access to data and facilitates cooperation, raising expectations regarding their potential contribution to achieving the SDGs.

To leverage the potential of digitalization to enhance economic growth with a lower environmental footprint [9], sustainability pillars—ecological, social, and economic—need to be coherently addressed [8]. Increasing numbers of sustainable ecosystems are being developed to better understand these global shifts and grasp the opportunities offered by the nexus between digitalization and sustainability [31]. The term “digital sustainability” was coined to provide a comprehensive picture of the convergence between these two phenomena [9,29,30]. George et al. (2021) [29] define digital sustainability as “the organizational activities that seek to advance sustainable development goals through the creative deployment of technologies that create, use, transmit, or source electronic data”. At the dawn of the digital era in agriculture, sustainability challenges are becoming increasingly prominent in new solutions, including in digital platforms’ business models designed to subordinate profit motives to the creation of a sustainable value [28,32]. Digital sustainability can therefore be considered a compelling window for knowledge development and sharing, enhanced communication, coordination, and trust, and for expanding access and spreading beneficial outcomes [9].

In recent literature, sustainability and resource management in the agri-food sector have emerged as key research topics due to global population growth, increased food demand, scarce natural resources, climate change, and socio-environmental challenges [5]. Sustainability in agriculture relies upon the harmonious integration of the three sustainability pillars [33–36]: the ecological pillar (e.g., ecological soundness, environmental conservation and improvement, productive capacity, and natural resource management, agroecological practices for sustainable agriculture), the social pillar (e.g., social responsibility, fulfillment of human needs, equity, justice, and fairness, building strong communities and resilient territories), and the economic pillar (e.g., the economic viability of agricultural business models, sustainable revenues and profits).

While there is a broad spectrum of optimism regarding the potential of digitalization to significantly address sustainability issues, the two phenomena are not necessarily aligned [9,37]. This intersection is only beginning to develop in recent years, and it remains unclear how both trends can be blended [32]. This is particularly relevant to digital platforms in the agricultural realm, where economic, environmental, and social challenges threaten business models and jeopardize sustainability. It is therefore important to consider the disruptive force of digitalization, which can negatively alter sustainable development if it is unintentional, mismanaged, or insufficiently assessed [10]. Brenner and Hartl (2021) [8] suggest that a thorough understanding of the relationship between these two mega-trends allows a better prediction of adverse patterns generated by digitalization that would impede socio-ecological advancement.

### 3. Materials and Methods

In line with previous research on the link between digitalization and sustainability [10, 31,32], this paper explores the conditions for convergence between digital platforms and sustainability through a qualitative research design. Our research aimed to build a deeper understanding of these two phenomena and investigate the prerequisites for an intersection between digital platforms and sustainability in the agricultural realm. As this convergence is an emerging area of inquiry, it is still unclear how they can be combined to create positive outcomes. The complex nature of this intersection can be adequately explored using a qualitative research design.

Drawing on expert interviews as our research method, we collected data through in-depth semi-structured interviews with an expert panel. According to Bogner, Littig, and Menz (2009), an expert is an individual who has specialized, process-related, and interpretative knowledge related to a domain. In addition to their systematically organized knowledge, experts have in-depth knowledge resulting from their specific experiences or responsibilities in a functional context [38]. Our participants were selected using purposeful sampling [39,40], a method that allowed for a deliberate and intentional approach to identifying experts who met our study criteria. We initially identified experts with a vast array of knowledge and perspectives that were relevant to our research. Then, we implemented the snowball technique to obtain further recommendations from participants, which allowed us to identify experts who were able to make significant contributions to our study. Table 2 provides a detailed overview of the qualifications and role specifications of the interviewed experts.

We aim to provide an overview of the conditions that digital platforms need to meet to foster their sustainability potential. To openly explore and gain a comprehensive understanding of our subject matter, a series of questions were developed to serve as a guide. These questions enabled us to explore the subject with precision and accuracy. The interview protocol utilized in this study was designed to be standardized while allowing for individual customization within each category of experts. To ensure consistency and accuracy throughout the interview process, all interviews were conducted by the first author. This approach served to maintain credibility within the research study. Our research methodology entailed a meticulous data collection and analysis process, conducted through iterative cycles. We also ensured the inclusion of relevant participants to refine our sample

of experts and obtain focused data for our study. The data collection process involved conducting up to sixteen semi-structured interviews. The interviews were concluded upon the attainment of theoretical saturation [41], signifying that no novel insights were being obtained on a given category or theme.

**Table 2.** Qualifications and role clarification of the interviewed experts.

Categories	Background and Expertise
Professionals	<p>A: Head of innovation, research, and development specializing in digital transformation in agriculture</p> <p>B: Digital transformation specialist with a focus on sustainability aspects in agriculture</p> <p>C: Sustainability manager at a crowdfunding platform that provides financial support to agricultural projects</p> <p>D: Project manager in charge of digital platform development in agriculture</p> <p>E: Digital platforms specialist</p> <p>F: Innovation and entrepreneurship manager tasked with assisting digital platform initiatives with a sustainability focus</p> <p>G: Senior program leader/project developer in agriculture, rural development, and Agri-tech</p>
Researchers and consultants	<p>H: Lecturer and researcher in strategy and entrepreneurship, Ph.D. in institutional economics. Research interests: Entrepreneurship, Innovation, Sustainable Innovation</p> <p>I: Senior Researcher in Sustainable Development Strategies, Sustainable Development, Sustainability, and Agricultural Philosophy</p> <p>J: Senior Lecturer with research and teaching focus on digital transformation in its many forms</p> <p>K: Ph.D. in management with a research focus on digital platforms, digital commons, democracy, and sustainability</p> <p>L: Farmer, lecturer, and author with valuable insights into the future of agriculture and its challenges in a fast-changing society</p> <p>M: Farmer and consultant in sustainable innovation and new technologies development in agriculture</p>
Co-founders of digital platform initiatives	<p>N: Software engineer, co-founder of a digital platform for knowledge-sharing in agriculture</p> <p>R: Entrepreneur with a double degree in agricultural engineering and ethics and sustainable development, co-founder of a digital peer-consulting platform</p> <p>S: Agricultural engineer, co-founder of a marketplace that specializes in providing agricultural products in France</p>

Before conducting interviews, the participants were requested to grant their consent for recording purposes. The length of the recorded interviews varied between 50 and 90 min and were securely transcribed and stored on a university file server by the first author. To ensure anonymity, we declared that the collected data will not be shared with third parties or made public.

The collected data was analyzed using NVivo 14 (Release 14.23.1) software through which the authors discussed and interpreted the codes and categories. The use of CAQDAS (Computer Assisted Qualitative Data Analysis Software) has enabled us to structure the collected data, identify themes, and draw conclusions from multiple sources of information [42,43], thus bringing additional clarity to the data analysis process [44]. We identified initial concepts and grouped them into categories through an open coding process. After categorizing our data, we performed axial coding to identify connections and create higher-order themes. Finally, we clustered similar themes into overarching dimensions that form the basis of our findings. This iterative process allowed us to gain a comprehensive understanding of emerging connections and patterns within the collected data.

#### 4. Results

With the advent of digital paradigms, agricultural practices are undergoing rapid transformations. Digital platforms play an important role in this dynamic and are a promising instrument for establishing new constellations of value-creation mechanisms in agriculture.



Drawing on our findings, four central dimensions emerged for a successful convergence between digital platforms and sustainability in agriculture: (1) the multidimensional scope of digital platforms in agriculture, (2) the role of digital platforms in promoting a holistic approach toward sustainability, (3) the necessity of farmers' involvement in building a sustainable digital platform, and (4) the significance of a comprehensive approach to unlocking the sustainability potential of digital platforms. We further outline the conditions for a convergence between the two phenomena (Table 3). To illustrate specific aspects of each dimension, relevant verbatim are provided in Appendix A.

**Table 3.** Conditions for a positive intersection between digital platforms and Sustainability in Agriculture.

Dimensions	Conditions
(1) The Multidimensional Scope of Digital Platforms in Agriculture <ul style="list-style-type: none"> <li>Promoting collaboration, connectivity, and collective intelligence</li> <li>Establishing new patterns of value creation in Agriculture</li> </ul>	<ul style="list-style-type: none"> <li>Integrating various stakeholders</li> <li>Building cohesive partnerships</li> <li>Adapting the digital platform to the specificities of the agricultural context</li> <li>Developing new practices and innovative business models</li> </ul>
(2) The Role of Digital Platforms in Promoting a Holistic Approach toward Sustainability <ul style="list-style-type: none"> <li>Promoting sustainable practices and widening access to necessary resources</li> <li>Fostering a responsible approach</li> </ul>	<ul style="list-style-type: none"> <li>Facilitating access to necessary resources</li> <li>Enabling farmers to gain more freedom to decide and innovate</li> <li>Integrating sustainability approaches into the design and implementation stages</li> <li>Expanding roles of stakeholders and increasing reciprocity</li> </ul>
(3) The Necessity of Farmers' Involvement in Building a Sustainable Digital Platform <ul style="list-style-type: none"> <li>Reflecting an image of sustainability and integrity</li> <li>Avoiding misalignments in the long-term</li> </ul>	<ul style="list-style-type: none"> <li>Actively engaging farmers in the design and implementation stages</li> <li>Placing farmers' interests at the center of the business model</li> <li>Enabling farmers to acquire new skills and devoting time to the adoption process</li> <li>Establishing change management programs to introduce farmers to digital platforms</li> </ul>
(4) The significance of a Comprehensive Approach to Unlocking the Sustainability Potential of Digital Platforms <ul style="list-style-type: none"> <li>Tackling sustainability pillars as part of a clear value proposition</li> <li>Widening access and outreach through communication channels and network effects</li> </ul>	<ul style="list-style-type: none"> <li>Building a strong understanding of digital platform features</li> <li>Demonstrating utility and practicality</li> <li>Providing evidence on the integrated sustainability approach</li> <li>Establishing an ecosystem that reflects trust and reliability</li> <li>Clarifying the governance mechanisms and ownership status</li> <li>Strengthening network effects and financial viability</li> </ul>

#### 4.1. The Multidimensional Scope of Digital Platforms in Agriculture

Our findings showed that digital platforms have established a solid foothold in agriculture and are paving new avenues for increased collaboration, sharing, and connectivity. The interviewed experts portrayed digital platforms as valuable and powerful matchmaking tools that can help reduce friction among farmers, advisors, and different actors involved in the value chain. Furthermore, digital platforms can be vehicles for developing collective intelligence to address sustainability issues in a meaningful manner. Our findings highlight, however, that articulating partnerships cohesively through the participation of different stakeholders is an important aspect that can be challenging for digital platforms' owners.

Digital platforms facilitate the exchange of tangible resources such as parcels and equipment on peer-to-peer platforms, access to fertilizers, seeds, and material on marketplaces, and financial resources on crowdfunding platforms. Digital platform ecosystems

can provide farmers with intangible resources such as practical information, peer insights, and new skills. These resources are essential for supporting the sustainable transition of their models. With access to these valuable tools, farmers can successfully navigate the challenges of modern agriculture and achieve their sustainability goals. The use of digital platforms for knowledge sharing and data valuation can be beneficial in this regard.

In a context where agriculture is facing major changes linked to digital transformation, the emergence of digital platforms offers possibilities for the development of new practices and allows the expansion of innovative entrepreneurial ventures and business models. These features can play a key role in attracting the youth to agricultural careers and in tackling socio-environmental challenges.

Digital platforms in agriculture embody a multidimensional phenomenon that dissolves traditional boundaries and fosters highly complex networks. Combined with traditional frameworks and considering the nuances specific to the agricultural context, they can provide unprecedented capabilities to explore, connect, and understand in innovative ways.

*“Agriculture has traditionally had a strong social dimension. This is evidenced by the cooperative structures that have always played an important role. In my opinion, farmers are strongly oriented toward collective action, mutual aid, and sharing of best practices. It seems that digital platforms have the potential to lead farmers forward in this direction.”*

(Participant A)

#### 4.2. The Role of Digital Platforms in Promoting a Holistic Approach toward Sustainability

By facilitating access to information, equipment, networks, and resources required to learn new skills, digital platforms can be a powerful tool to improve agricultural practices and foster economic, social, and ecological sustainability. The interviewed experts assert that digital platforms constitute a real vehicle for diffusion and affordability, enabling farmers to regain their entrepreneurial capacity and freedom of choice.

*“As natural resources become increasingly scarce, farmers are constantly challenged to evolve their practices. Digital platforms are one way of providing them with the necessary tools to facilitate these complex shifts.”* (Participant D)

Digital platforms are at the forefront of driving socio-ecological transformations through the development of sustainable agricultural approaches and a purpose-driven mindset. The intangibility of digital platforms implies unlimited possibilities to reuse the data accumulated in different functional settings and to increase reciprocity, thus allowing farmers to overcome geographical boundaries. A digital platform provides farmers with a new means for boosting their income and diversifying their revenues, thus bypassing traditional distribution channels, e.g., Short Distribution platforms: LaRucheQuiDitOui!, ViteMonMarché, Agrilocal, HorsNormes, these initiatives are focused on enhancing local production networks, fostering the sustainability of small-scale farming operations, and promoting the adoption of ecological farming practices among stakeholders utilizing a digital platform.

Considering their potential to reshape transactions in a decentralized, open-access, reliable, and efficient way, numerous entrepreneurial actors in agriculture are deploying digital platforms to address key sustainability challenges. Crowdfunding and knowledge-sharing platforms for example develop business models that integrate sustainability approaches within technological innovations purposefully designed to meet socio-ecological requirements. In this way, digital platforms offer tremendous potential to tackle societal challenges in the agricultural realm. They can actively contribute to increasing awareness of environmental imperatives and the necessity to expand the roles of different actors to create ecological and social values.

It is important to highlight that digital platforms in agriculture are sometimes subject to unrealistic promises and disproportionate expectations. If not properly engineered and implemented, they could result in negative environmental impacts associated with e-waste,

increased energy consumption, and pollutant emissions. Digital platforms as artifacts do not offer a virtuous value per se, it is how they are designed and used that gives them meaning.

#### 4.3. The Necessity of Farmers' Involvement in Building a Sustainable Digital Platform

Fostering farmers' participation is necessary for the development of digital platforms in the agricultural landscape. Engaging them in the design and implementation phases is key to unlocking greater value and utility from the ecosystems enabled by digital platforms. It is also an essential asset to ensure that the value proposition encompasses economic, social, and environmental dimensions in a relevant manner.

*"For me, farmers' participation in these platforms is non-negotiable! They should be involved in the creation and implementation processes. This could be the main guarantee of return on investment in the long term."* (Participant H)

The interviewed experts pointed out that placing farmers at the center of digital platforms' business models is a powerful way to prevent misalignments and promote the spread of virtuous outcomes in a sustainable way. As such, digital platform owners should actively engage farmers, federate them around their activities, and systematically engage them as beta testers, rather than placing them in the position of customers. This active participation is key to ensuring that digital platforms deliver sustainable, human-centered, and meaningful value by promoting fairness, accountability, and transparency.

*"Farmers are not customers; they are producers by nature who cultivate their land to provide for their community. Digital platform owners should think of them as such and engage them throughout the entire process."* (Participant J)

Our findings also highlight that actively involving farmers is not straightforward. It is a process that requires time, dedication, and new skills. Being at the center of the business model, farmers need to learn new ways of creating activities on a digital interface, implementing new communication methods, and sharing a variety of complex data, etc. It is therefore essential to implement training programs to introduce farmers to digital ecosystems and assist them in the transition process.

#### 4.4. The Significance of a Comprehensive Approach to Unlocking the Sustainability Potential of Digital Platforms

Digital platforms are gaining momentum in the agricultural sphere, with farmers gradually adopting them as a response to acknowledged needs. As part of the process of establishing a comprehensive approach to digital platform expansion, the interviewed experts highlighted that one of the key conditions lies in demonstrating their usefulness and practicality through a clear and well-articulated value proposition. The spread of digital platforms in agriculture may remain within limits if the value proposition is not grounded in the reality of farmers and does not enable them to implement solutions tailored to their specific contexts.

The implementation of cutting-edge agricultural solutions may require a longer period than in other industries. Nevertheless, a substantial proportion of farmers are receptive to investigating novel opportunities. Thus, providing evidence on the potential of digital platforms to tackle sustainability pillars is a prerequisite for a thorough understanding of these tools and their underlying functionalities. An in-depth comprehension of digital platforms is key to achieving greater efficiency and wider dissemination. Furthermore, digital affordance enabled by these platforms is a building block that needs to be more clarified and valued, farmers and different stakeholders should be able to perceive digital platforms as tools that empower them rather than as a disruptive force that threatens their traditional models.

*"Using a digital platform means that a farmer can access any information and any equipment by simply visiting a website or an app on their device. This is very empowering!"* (Participant B)



The network effect is also a key factor in the development of a digital platform. Numerous digital platforms created in the agricultural sector have fallen off the market over the last five years. This raises concerns regarding their financial viability. Digital platforms in agriculture tend to rely on institutional or donor funding. In this regard, defining a clear business model with associated revenue streams is required. It is also important to gain visibility and engage as many stakeholders as possible to widen the scope of possible positive outcomes.

Our findings further indicate that establishing an ecosystem that reflects trust, reliability, and accountability is a prerequisite for digital platforms to meaningfully address sustainability issues. Concerns regarding the intended use of the data collected may discourage farmers from participating in these ecosystems. It is therefore necessary to clarify the ownership status of the platform to provide better inputs through inclusive and participatory approaches.

## 5. Discussion

This paper examined the emerging landscape of digital platforms in agriculture in conjunction with sustainability challenges from a holistic perspective. The identified conditions apply to digital platforms in agriculture at each of the specified levels (Upstream, Intermediate, and Downstream levels).

According to recent literature, using digitally enabled solutions can help meet sustainability challenges [28,29]. Digital platforms are considered to be particularly effective in bringing together multiple stakeholders [31]. The digital aspect of these initiatives opens the doors to greater scalability while breaking geographical boundaries, resulting in broader reach and impact [31]. As the economic models in agriculture are volatile and the level of complexity and agronomy required to implement new processes is increasing, this leads farmers to strive for economic viability, environmental efficiency, and social stability. To address these concerns, a shift toward more sustainable models is required [5,36,45–47]. This transition entails technical, cognitive, socio-economic, organizational, and personal challenges [15]. In this article, we argued that digital platforms are an integral part of the agricultural transformation and are a promising instrument for establishing new constellations of value-creation mechanisms. However, this potential is contingent upon the fulfillment of the identified prerequisites.

### 5.1. Theoretical Implications

This paper contributes to the development of a broad new field of research on the link between digitalization and sustainability [1,7,29,31,32,48–50]. Our findings indicated that sustainable agriculture transitions can be facilitated with the rise of digital platforms, provided that certain requirements are met, and drawbacks are carefully monitored to foster long-term sustainability.

This intersection has given rise to a plethora of new concepts in recent literature, such as “digital sustainability” [29,30]. We further explore this emerging concept as a theoretical ground for investigating this intersection in agriculture. Digital solutions have been recognized as a way to provide opportunities to create new models that encompass environmental, social, and economic value [31]. We add to this by showing that digital platforms are groundbreaking solutions for the development of new ventures in agriculture. They provide innovative resources to create new patterns of value creation in the agricultural sphere. As such, they represent an alternative approach to attracting the youth to agricultural careers and strengthening the economic viability of agricultural business models. We argue that this is one possible response to the generational renewal challenge in agriculture.

Platform ownership has been stated as a key factor in the design and governance of digital platform ecosystems [20,25]. Platform ownership goes beyond guaranteeing access to legal disclosures, it is a broader construct involving both the distribution of power within the platform and the relationships between the participating partners [20]. We add to this by demonstrating that fostering network participation is key to the development of digital

platforms. Our research shows that engaging farmers in the process of designing and implementing digital platforms can significantly enhance their overall value, mitigate potential misalignments, and promote social responsibility. This approach emphasizes a collaborative and inclusive approach that can yield significant long-term benefits for all stakeholders involved.

### *5.2. Practical Implications*

When designed and implemented responsibly, digital platforms can be leveraged as empowering tools for achieving sustainability goals in agriculture, thus leading to sharper beneficial outcomes. However, the potential of digital platforms to foster sustainability pillars in agriculture remains controversial and insufficiently investigated. Open issues related to the lack of understanding of their added value and their potential virtuous outcomes in the agricultural sector continue to emerge. In this paper, we elaborated on this potential, arguing that a clear understanding of the underlying features of digital platforms is a major step toward unleashing their transformative capabilities.

Achieving a successful intersection between digital platforms and sustainability is neither straightforward nor challenge-free. This paper provides practical insights to help implement a sustainability approach within the field of digital platforms. Practitioners can draw on the identified conditions that enable convergence between digital platforms and sustainability in agriculture. The identified dimensions can also serve as a starting point for designing new solutions that blend a socio-ecological value.

Digital platforms embody a fundamental upheaval in agriculture, bringing profound organizational and operational shifts. However, many platforms today are still in the embryonic stage, lacking full development, or have vanished within the space of a few years. This translates into numerous concerns, including the network effect central to developing a digital platform and the long-term financial stability that is often challenged. Therefore, unlocking the potential of digital platforms to achieve sustainability goals entails learning from past failures and supporting resilient initiatives. Additionally, placing farmers' needs at the center of the business model is an essential step to ensuring that digital platforms are accessible and valuable.

### *5.3. Limitations and Future Research*

There are limitations to this article that can offer a baseline for future research. We sought to explore the intersection between digital platforms and sustainability in agriculture by employing a qualitative research design [10,31,32]. The identified conditions contribute to developing the field of research related to digital platforms in conjunction with sustainability challenges. Future research could extend the expert panel to deepen our findings and use quantitative approaches to develop the insights provided in this paper. Case studies are another approach to exploring the potential contributions of a particular category of digital platforms to sustainability pillars. Future academic research can be conducted on the potential benefits of crowdfunding and knowledge-sharing platforms. These categories have shown promise as effective tools for promoting collaboration and innovation and could be valuable areas for future academic inquiries.

In this article, we show that farmers' participation in the ecosystem of digital platforms in agriculture is a prerequisite to meeting sustainability goals. Future research can build on our findings to broaden the scope of the investigation to explore the contribution of other relevant stakeholders, notably within the institutional and entrepreneurial landscape of agricultural innovation.

Our paper highlighted several negative outcomes that may result from using digital platforms. Further studies are needed to analyze the life cycle of digital platforms and assess their environmental footprint and social implications. We argue that an objective and critical approach to studying the intersection of the two phenomena will lead to a clearer perspective on the potential of digital platforms and help keep any adverse outcomes within bounds.

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## Appendix A

**Table A1.** Verbatim illustrations spotlighting the identified dimensions.

Dimensions	Verbatims
(1) The Multidimensional Scope of Digital Platforms in Agriculture	<p>“The emergence of digital platforms is becoming more and more relevant, and they will be gradually adopted by farmers for a very simple reason: they are driven by environmental and social concerns, and they are eager to engage in sustainable practices.”</p> <p>“Digital platforms enable farmers to share experiences and connect with peers with similar interests who may not necessarily be neighbors. Digital platforms act as a vector that allows farmers to collaborate and work together.”</p> <p>Promoting collaboration, connectivity, and collective intelligence</p>
	<p>“Digital platforms hold the potential for creating new business models that bring the right balance of people, planet, and profit.”</p> <p>“I believe that digital platforms that have been created in the agricultural field can play a significant role in improving the attractiveness of the agricultural profession, in this sense, they are very valuable assets.”</p> <p>Developing new patterns for value creation</p>
(2) The Role of Digital Platforms in Promoting a Holistic Approach toward Sustainability	<p>“The increasing scarcity of resources is driving agriculture to alter its current practices while reducing greenhouse gas emissions as much as possible. These are complex issues, and solutions can be extremely challenging.”</p> <p>“Digital platforms can provide the means for introducing farmers to the use of digital tools to address sustainability issues in a meaningful way.”</p> <p>Promoting sustainable transitions</p>
	<p>“There are several digital platform projects that are addressing issues related to sustainability. Through digital affordances, they can contribute to overcoming the lack of knowledge or misunderstanding regarding agricultural practices and legislation that is constantly evolving.”</p> <p>“The use of digital platforms can generate a certain amount of e-pollution since they require scarce materials and energy-intensive storage space to operate. I haven’t yet encountered a report that considers and analyzes the life cycle of these platforms and compares their use with traditional systems to make a comparison in terms of pollution. In my opinion, including an indicator related to these aspects in the study of digital platforms will be a major step forward.”</p> <p>Spreading virtuous practices through digital affordance and narrowing environmental footprints</p>

Table A1. Cont.

Dimensions	Verbatims
(3) The Necessity of Farmers' Involvement in Building a Sustainable Digital Platform	"To reflect an image of integrity and build trust and reliability, it is essential to involve farmers in the design and implementation process, and this is an effective approach to avoid misalignment of digital platforms in the agricultural context."
	Reflecting an image of sustainability and integrity
(4) The significance of a Comprehensive Approach to Unlocking the Sustainability Potential of Digital Platforms	"There are three things to consider for achieving sustainability. First, we need to accept that digital transition is a process that requires time to be implemented. Second, we need to involve as many farmers as possible in the process without falling into elitism. And third, we need to allocate the necessary resources to accelerate this process, to innovate, and to move forward collectively."
	Dedicating the necessary resources to ensure a positive intersection
	"To understand the rise of digital platforms in agriculture and the opportunities they offer, a shift in mindset is needed. All stakeholders involved in the value chain should be capable of viewing these platforms as a practical tool that can directly improve their activities."
	Addressing sustainability pillars within a clear value proposition
	"To ensure that all three pillars of sustainability are interconnected and expand the scope of positive externalities, it's important to understand that a digital platform implies an exchange within a community that is large enough to allow interactions to occur. Otherwise, we will end up with an empty restaurant phenomenon, with far more platforms offering their services than there are people interested in joining the ecosystem."
	Expanding the scope of positive outcomes through network effects

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