

Original Paper

Farmers' Awareness of Digital Transformation and Its Implications for Sustainable Agricultural Development in Vietnam

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Abstract

Digital transformation is creating new opportunities for improving agricultural productivity, resource efficiency, market access, and resilience. However, these benefits depend not only on technological availability but also on farmers' capacity to understand and engage with digital technologies. This study examines farmers' awareness of digital transformation in Vietnam and explores its implications for sustainable agricultural development. Drawing on published empirical studies, systematic reviews, and relevant policy and institutional reports, the study synthesizes evidence on farmers' awareness and understanding, differences across farmer groups, and the factors associated with these differences. The findings indicate that digital awareness remains uneven, with more advanced technologies generally less well understood than familiar or established applications. Education, digital skills, Internet access and proficiency, participation in training, exposure to pilot models, and production conditions emerge as important factors associated with differences in awareness. These disparities have broader implications for sustainable agriculture, as unequal digital capabilities may limit farmers' opportunities to benefit from improvements in production efficiency, resource management, market access, and environmentally responsible practices. The study argues that farmers' awareness should be viewed as an enabling condition rather than a direct determinant of sustainable agricultural outcomes. It concludes that agricultural digitalization in Vietnam requires a farmer-centered approach that combines technological investment with differentiated digital training, practical demonstration, technical support, and inclusive access. Such an approach is essential to ensure that digital transformation contributes to economically viable, environmentally sustainable, and socially inclusive agricultural development.

Keywords

agricultural digitalization, digital awareness, digital transformation, farmers, sustainable agriculture, Vietnam

1. Introduction

Digital transformation is reshaping agriculture by changing how farmers access information, manage production, connect with markets, and make decisions. Digital platforms, mobile applications, remote sensing, artificial intelligence, the Internet of Things (IoT), and data-driven management tools are increasingly being incorporated into agricultural production and value chains. Their potential extends beyond productivity gains: when appropriately designed and adopted, digital technologies can support more efficient use of inputs, improve access to markets and advisory services, strengthen resilience, and contribute to more sustainable agricultural systems (Khanna, 2020; Rijswijk et al., 2021; Gumbi et al., 2023; Yuan & Sun, 2024). Digital transformation in agriculture should therefore be understood not simply as the introduction of new technologies, but as a broader process through which production practices, information flows, market relations, and farm management are reorganized.

This transition is particularly relevant to Vietnam, where digital transformation is increasingly linked to the modernization and green transition of agriculture. Recent initiatives illustrate how digital tools can serve both economic and environmental objectives. For example, the Ministry of Agriculture and Rural Development and the United Nations Development Programme introduced an electronic traceability system for dragon fruit in Binh Thuan that enables product origin and carbon-footprint information to be traced through QR codes. Such applications demonstrate how digitalization can support transparency, low-carbon value chains, and access to markets with increasingly stringent environmental requirements. At the same time, significant constraints remain. Rural digital infrastructure is uneven, digital applications are not yet sufficiently synchronized across regions, investment capacity remains limited, and farmers' awareness and skills in using smart devices continue to constrain the wider diffusion of digital agriculture (UNDP, 2023).

These challenges draw attention to the role of farmers themselves in the digital transformation process. Technology can be made available, but its availability alone does not ensure meaningful use. Before farmers decide whether to adopt a digital technology, they must first be aware of it and develop an adequate understanding of its functions, expected benefits, requirements, and relevance to their farming activities. In this sense, awareness and understanding represent an important cognitive foundation for subsequent technology adoption. Evidence from Vietnam also suggests that exposure to agricultural technology does not necessarily translate into a sufficient understanding of newer technologies. A survey of 248 farm households across 89 villages in the Central Highlands found that farmers were relatively familiar with simple and long-established agricultural technologies, whereas newer and more advanced technologies remained poorly understood (Tran & Tran, 2025). This distinction is important because it shifts the analytical focus from whether technologies are available to whether farmers have the knowledge and capacity required to engage with them.

More direct evidence on digital transformation reveals a similar pattern. Based on a structured survey of 230 farming households in Vietnam's Red River Delta, Luu and Le (2025) measured farmers' understanding of digital transformation using a 35-item instrument and reported an average score of only

15.8 out of 35. Their analysis further showed that farmers' levels of understanding were associated with educational attainment, farm type, Internet proficiency, participation in digital-transformation training, exposure to pilot models, and land size. These findings are consistent with an earlier study in Thai Binh Province, which also reported relatively low levels of farmers' understanding and identified education, proficiency in technological devices, training participation, exposure to pilot models, production type, and land size as important determinants (Le, 2024). Taken together, this evidence suggests that farmers do not enter the digital transition from an equal starting point; their ability to understand and potentially benefit from digital transformation is shaped by differences in education, digital capabilities, production conditions, and access to learning opportunities.

Evidence on actual technology use further reinforces the importance of these differences. In a survey of 455 smallholder farmers in Quang Tri Province, Uy et al. (2025) found that education, farm size, digital experience, access to digital information, knowledge-exchange frequency, and Internet costs were among the factors positively associated with digital technology adoption. The authors consequently emphasized the need for differentiated training and targeted extension interventions rather than uniform approaches to promoting digital agriculture. The relevance of such findings extends beyond technology adoption itself. If the knowledge, skills, and opportunities needed to engage with digital agriculture are unevenly distributed, digital transformation may reproduce or deepen existing disparities between farmers rather than automatically generating inclusive benefits.

This concern is particularly important when digital transformation is considered in relation to sustainable agricultural development. Sustainability requires more than technological modernization or higher productivity. It also involves the efficient use of natural resources, environmental protection, economic viability, resilience, and the capacity of different social groups to participate in and benefit from development. Digital technologies may contribute to these objectives by improving access to production and market information, enabling more precise resource management, facilitating traceability, and supporting environmentally responsible practices (Rijswijk et al., 2021; Gumbi et al., 2023; Qin et al., 2022). Yet these potential benefits depend, at least in part, on farmers' ability to recognize, understand, and make informed use of digital opportunities. Farmers' awareness of digital transformation is therefore not merely a technological issue; it is also a question of human capability and inclusive participation in the transition toward sustainable agriculture.

Despite the growing body of research on digital agriculture in Vietnam, an important gap remains. Existing empirical studies have provided valuable evidence on farmers' understanding of digital transformation in particular localities and on the determinants of digital technology adoption (Le, 2024; Luu & Le, 2025; Uy et al., 2025). However, this evidence remains fragmented across locations and analytical concerns. Less attention has been paid to bringing these findings together to examine what variations in farmers' awareness and understanding imply for the broader transition toward sustainable agriculture in Vietnam. In particular, the implications of unequal awareness across farmer groups for the economic, environmental, and social dimensions of sustainability remain insufficiently synthesized.

Addressing this gap is important for moving the discussion beyond the provision of digital technologies toward the conditions under which farmers can meaningfully participate in and benefit from agricultural digitalization.

Against this background, this study examines **farmers' awareness and understanding of digital transformation in Vietnam and considers their implications for sustainable agricultural development**. Drawing on existing empirical studies and secondary evidence, it addresses three questions: **(1)** What does the available evidence reveal about farmers' awareness and understanding of digital transformation in Vietnam? **(2)** Which individual, farm-level, and enabling factors are associated with differences in farmers' awareness and understanding? and **(3)** What do these patterns imply for the promotion of economically viable, environmentally sustainable, and socially inclusive agricultural development?

The study makes two contributions. First, it advances a farmer-centered perspective on agricultural digitalization by treating farmers' awareness and understanding as socially differentiated rather than assuming that technological opportunities are equally accessible to all. Second, it connects these differences to the broader sustainability agenda, highlighting how education, digital capabilities, production conditions, training, and access to technological learning opportunities may shape farmers' capacity to participate in the digital transition. In doing so, the study provides an evidence-based foundation for more targeted digital-skills development, agricultural extension, and digitalization policies that are responsive to the diverse circumstances of farmers in Vietnam.

2. Theoretical Background and Analytical Framework

2.1 Digital Transformation in Agriculture

Digital transformation in agriculture involves the integration of digital technologies into farming, farm management, information exchange, and market activities. It extends beyond the adoption of individual technologies to changes in how farmers access information, organize production, make decisions, and interact with markets and agricultural services. When effectively integrated into farming systems, digital technologies can improve productivity and resource-use efficiency, expand access to information and markets, and strengthen agricultural resilience, thereby supporting more sustainable agricultural development (Khanna, 2020; Rijswijk et al., 2021; Gumbi et al., 2023).

2.2 Farmers' Awareness of Digital Transformation

Farmers' awareness is a critical dimension of agricultural digital transformation because the effective use of digital technologies depends partly on how farmers understand and evaluate their relevance to farming. In this study, digital transformation awareness refers to farmers' recognition and understanding of digital technologies and their perceptions of the benefits, feasibility, and constraints associated with their use in agricultural activities.

Drawing on the available literature, farmers' awareness is examined through four interrelated dimensions: (i) recognition of digital transformation and relevant agricultural technologies; (ii) understanding of their

practical applications; (iii) perceived benefits for production, information access, market participation, and environmental performance; and (iv) perceived feasibility and barriers to adoption. Conceptually, these dimensions can be expressed as:

Recognition → Understanding → Perceived benefits → Perceived feasibility.

This framework distinguishes awareness from actual adoption. A farmer may recognize and understand the potential benefits of digital technologies without necessarily adopting them, particularly when constrained by limited skills, financial resources, infrastructure, or technical support.

2.3 Factors Associated with Farmers' Digital Awareness

Farmers' awareness of digital transformation does not develop uniformly. Available empirical evidence indicates that it varies according to individual characteristics, production conditions, and access to digital resources and learning opportunities. Relevant factors include age, gender, education, farming experience, farm size and production type, Internet and digital-device use, participation in training, and exposure to digital-transformation initiatives or pilot models.

The analytical framework of the study is therefore structured as follows: *Individual characteristics + Production conditions + Access to digital technology and training → Digital transformation awareness → Implications for sustainable agricultural development.*

The framework does not assume a direct causal relationship between farmers' awareness and sustainable agricultural outcomes. Instead, it uses the economic, environmental, and social dimensions of sustainability to interpret the broader implications of differences in digital awareness. This approach allows the study to examine how uneven awareness and access may influence farmers' capacity to participate in and benefit from agricultural digital transformation while remaining consistent with the scope of the available secondary evidence.

3. Research Questions and Methodology

This study examines farmers' awareness of digital transformation and its implications for sustainable agricultural development in Vietnam. It addresses four research questions: (1) What is the current level of farmers' awareness and understanding of digital transformation in agriculture? (2) How does digital awareness vary across farmers with different demographic characteristics, production conditions, and levels of access to digital technologies? (3) Which factors are associated with differences in farmers' digital awareness? and (4) What do these patterns imply for promoting sustainable agricultural development in Vietnam?

The study adopts a secondary-data research design combining a structured review of the literature with comparative synthesis of existing empirical evidence. The analysis draws primarily on published studies of farmers' awareness and understanding of digital transformation in Vietnam, particularly empirical evidence from Thai Binh and the Red River Delta, complemented by studies of digital technology adoption among farmers in Vietnam and other developing-country contexts. Relevant systematic reviews on smallholder digitalization and sustainable digital agriculture are also considered, together with official

Vietnamese policy documents and institutional reports on agricultural digital transformation and sustainable development. The existing reference base includes studies directly addressing farmers' understanding of digital transformation as well as broader research on digital agriculture and sustainability.

The analysis proceeds in three stages. First, the available evidence is synthesized to assess farmers' awareness and understanding of digital transformation. Second, findings are compared across individual characteristics, production conditions, and access to digital technologies and training to identify factors consistently associated with variations in awareness. Third, these findings are interpreted in relation to the economic, environmental, and social dimensions of sustainable agricultural development. Statistical estimates reported in the original studies are used as published; no new regression or causal analysis is performed. This approach enables systematic use of existing evidence while avoiding causal claims that cannot be supported by the available secondary data.

4. Results and Discussion

4.1 Farmers' Awareness of Digital Transformation

Available evidence suggests that farmers' awareness of digital transformation remains uneven. While many farmers are familiar with commonly used digital tools and recognize the growing role of technology in agriculture, their understanding of more advanced digital applications is generally more limited. This gap is particularly evident in technologies that require higher levels of digital knowledge, technical skills, or investment. Evidence from Vietnam shows that farmers tend to be more familiar with established agricultural technologies than with newer and more sophisticated applications.

Farmers' awareness can be understood across four related dimensions: recognition of digital technologies, understanding of their practical applications, perceived benefits, and perceived feasibility of adoption. Farmers generally perceive digital technologies as potentially useful for accessing information, improving production management, and connecting with markets. However, recognizing these benefits does not necessarily imply that farmers feel capable of applying the technologies in practice. This distinction between awareness and practical feasibility is important for understanding the current stage of agricultural digital transformation in Vietnam.

4.2 Differences in Digital Awareness across Farmer Groups

Digital awareness is not evenly distributed across the farming population. Existing studies indicate variations associated with education, farm characteristics, digital experience, Internet use, and participation in training or pilot programs. Farmers with higher educational attainment and greater familiarity with digital devices tend to demonstrate a better understanding of digital transformation. Training and exposure to practical digitalization models also appear to be associated with higher levels of awareness.

Differences by age, gender, farming experience, and farm size are less consistent across studies and should therefore be interpreted cautiously. Rather than assuming that demographic characteristics alone

determine digital awareness, the evidence points to the importance of the opportunities and resources available to different groups. These differences suggest that a uniform approach to agricultural digitalization may not adequately address the diverse capacities and circumstances of Vietnamese farmers.

4.3 Enablers and Barriers to Farmers' Digital Awareness

The evidence identifies several conditions that may facilitate or constrain farmers' awareness of digital transformation. Digital skills, access to reliable information, participation in training, and exposure to demonstration or pilot models emerge as important enabling factors. These mechanisms can make digital technologies more understandable and allow farmers to evaluate their relevance to actual farming practices.

Conversely, limited digital skills, inadequate infrastructure, investment costs, insufficient technical support, and fragmented access to information may restrict farmers' engagement with digital transformation. These barriers often interact rather than operate independently. For example, access to the Internet may have limited value when farmers lack the skills to identify and use relevant agricultural information. Similarly, awareness of potential benefits may not lead to meaningful engagement when technologies are perceived as costly, complex, or poorly suited to local production conditions. The findings therefore suggest that improving awareness requires more than simply expanding technological access; it also requires appropriate training, practical guidance, and locally relevant applications.

4.4 Implications for Sustainable Agricultural Development

The implications of farmers' digital awareness can be considered across the economic, environmental, and social dimensions of sustainable agriculture. Economically, greater awareness may enable farmers to make better use of digital information, production-management tools, and market platforms, potentially improving efficiency, market access, and farm performance. Environmentally, understanding digital and precision technologies may facilitate more efficient use of water, fertilizers, pesticides, and other inputs and support the adoption of greener production practices. Existing literature in the study's reference base provides evidence linking agricultural digitalization with resource efficiency, resilience, and sustainable transformation.

The social dimension is equally important. Unequal levels of education, digital skills, technological access, and training opportunities may create a digital divide among farmers, leaving some groups less able to participate in and benefit from agricultural digitalization. Sustainable digital transformation therefore requires not only technological investment but also inclusive capacity building and differentiated support for farmers with varying levels of digital readiness.

Taken together, the findings suggest that farmers' awareness should be viewed as an enabling condition rather than a direct determinant of sustainable agricultural outcomes. Raising awareness alone is unlikely to produce sustainable transformation unless it is accompanied by improved digital capabilities, accessible infrastructure, appropriate technologies, technical support, and opportunities for practical learning. From this perspective, a farmer-centered approach is essential to ensure that agricultural

digitalization contributes simultaneously to economic viability, environmental sustainability, and social inclusion.

5. Conclusion and Policy Implications

This study highlights farmers' awareness as an important enabling condition for agricultural digital transformation in Vietnam. The available evidence suggests that awareness and understanding remain uneven across farmer groups and are associated with differences in education, digital skills, production conditions, access to technology, and participation in training. These disparities matter for sustainable agricultural development because the benefits of digitalization depend not only on the availability of technology but also on farmers' capacity to understand, access, and use it effectively.

The findings point to four policy priorities. First, efforts to improve farmers' awareness and understanding should accompany investment in digital infrastructure and technologies. Providing technology without strengthening farmers' capacity to engage with it may limit its practical value. Second, digital training should be differentiated according to farmers' skills, production characteristics, and levels of digital experience rather than delivered through a uniform approach. Training should emphasize practical applications that address farmers' specific production and market needs.

Third, demonstration and pilot models should be expanded to allow farmers to observe and experience the tangible benefits of digital technologies. Linking these models to measurable outcomes, such as lower input costs, improved productivity, better market access, or more efficient resource use, may help translate general awareness into informed engagement. Existing evidence in the study's reference base identifies training and exposure to pilot models among the factors associated with farmers' understanding of digital transformation.

Finally, agricultural digitalization policies should explicitly address inequalities in digital access and capability. Particular attention is needed for farmers with limited digital skills, fewer resources, or restricted access to training and technological support. An inclusive approach can help prevent digital transformation from widening existing disparities and strengthen its contribution to economically viable, environmentally responsible, and socially inclusive agricultural development.

Overall, sustainable agricultural digitalization requires a shift from a predominantly technology-centered approach toward a farmer-centered one. Technology investment, digital capacity building, practical learning, and inclusive access should be pursued together so that farmers are not merely recipients of digital technologies but active participants in Vietnam's transition toward sustainable agriculture.

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