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Smart Agriculture in Southeast Asia: Digitization of Smallholders through Organizational Commitment and Collective Ambition

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ABSTRACT

Smart agriculture aims to improve agricultural sustainability output and earnings, increase resilience to climate change, mitigate greenhouse gas emissions, and promote Sustainable Development Goal 2. Understanding the internal organizational factors influencing digital transformation and digital maturity among farmers is crucial to achieving smart agriculture. This study collected a sample of 287 farmers from Indonesia, Malaysia, Thailand, Vietnam, and Cambodia across 15 agricultural zones. The study examines collective ambition through the lens of the theory of acceptance model (TAM) and organizational commitment through the unified theory of acceptance and use of technology (UTAUT), using partial least square structural equation modelling (PLS-SEM). The findings show that collective ambition and organizational commitment have a significant and positive impact on digital transformation and digital maturity. The integration of TAM and UTAUT validates collective views of technology usability, social influence, and effort expectations as essential social mechanisms for coordinated action, sustained engagement, and enduring digital transitions.

Keywords: Collective ambition, digital maturity, digital transformation, organizational commitment, smallholders, and smart agriculture

1. Introduction

Agriculture is crucial for meeting food requirements and achieving sustainable development. Beyond food production, the sector contributes to ecosystem preservation, biodiversity conservation, and the sustainable use of natural resources, thereby supporting economic growth (Bistline et al., 2022). Southeast Asia (SEA) occupies a strategic position in global food production, serving both regional consumption and international food markets (Tan & Kuebbing, 2023). Despite its importance, the agricultural sector in SEA is highly vulnerable to climate change, which has become one of the most significant threats to food security in Asia. Rising temperatures, prolonged droughts, and extreme weather events have contributed to persistent declines in agricultural productivity across many regions (Lesk et al. 2016). These impacts are particularly severe for smallholder farmers, as they reduce crop yields, threaten household incomes, and undermine rural livelihoods, with broader consequences for global food security (IPCC, 2014). In response to these challenges, the *Sustainable Development Goals* (SDGs) emphasize the importance of digital transformation in agriculture (Damba et al., 2020). Smart agriculture integrates digital technologies such as the Internet of Things (IoT), cloud computing, big data analytics, and artificial intelligence (AI) to enable data-driven agricultural management across the value chain (Trendov et al., 2019). These technologies can enhance productivity, reduce operational costs, and support more informed decision-making (Quy et al. (2022). Therefore, smart agriculture is expected to improve the sustainability of agricultural production and income, strengthen adaptation to climate change, reduce greenhouse gas emissions, and contribute to the achievement of SDG 2 (*Zero Hunger*) and SDG 13 (*Climate Action*) (Azadi et al., 2021).

According to FAO (2023), smallholder farmers cultivating less than two hectares of land contribute more than one-third of global food production. Although five-sixths of the world's farms operate on less than two hectares and collectively occupy only 12% of agricultural land, they produce approximately 35% of the global food supply (Lowder et al., 2021), as smallholder farmers crucial role in ensuring food security. Nevertheless, global food systems continue to face significant challenges, as approximately 10.8% of the world's population remains undernourished, while billions of people suffer from micronutrient deficiencies or diet-related health problems (Veldhuizen et al., 2020). Addressing these challenges requires improving the productivity and resilience of smallholder farmers through access to technical support, knowledge, and innovative farming practices (Mujeyi et al., 2021). Smart agriculture offers a promising pathway by integrating digital technologies and data-driven management practices to improve agricultural efficiency and sustainability. Such approaches enable farmers to optimise resource use, reduce environmental impacts, and make more informed production decisions (Schnebelin et al., 2021). The successful implementation of smart agriculture requires technological infrastructure, analytical capabilities, experiential knowledge, and access to accurate information. These capabilities help farmers accelerate production processes, mitigate risks, monitor farm performance in real time, and optimise costs while maintaining product quality (Veldhuizen et al., 2020). Because smart agriculture combines biological, environmental, and digital systems, it represents a knowledge-intensive ecosystem that requires transdisciplinary insights to better understand the complex interactions between farming activities and their surrounding environments (Vishnoi & Goel, 2024).

While existing studies have extensively highlighted the technological benefits of smart agriculture (Bwambale et al., 2023; Javaid et al., 2022; Kernecker et al., 2020; Lova Raju & Vijayaraghavan, 2022; Michels et al., 2020), considerably less attention has been paid to the organizational mechanisms that enable farmers to adopt and effectively utilize digital technologies. This limitation suggests the need to examine how shared aspirations, organizational commitment, and technology acceptance processes collectively influence digital transformation in agriculture. According to Ready & Truelove, (2011), collective ambition can offer a clear and stable direction in environments characterized by continuous, large-scale, and rapid change. For the effective adoption of technology, collective ambition can be grounded in established frameworks within information science and business research. Previous empirical studies have demonstrated that the *technology acceptance model* (TAM) is a robust and widely utilized theory for explaining the adoption of new technologies. Davis et al. (1989) conceptualizes TAM as one of the most influential models for explaining technology adoption, with two main factors influencing an individual's intention to use technology: *perceived usefulness* (PU) and *perceived ease of use* (PEOU). Kets de Vries (2025) conceptualized collective ambition as strengthening an organization's dedication by harmonizing the shared aspirations and values of its members, which instills a sense of ownership, active involvement, and commitment to reaching shared goals. Meyer & Allen (2001) conceptualize organizational commitment as a multidimensional construct, encompassing normative, continuance, and affective components, each associated with an organization's willingness to invest in and institutionalize new technologies. Venkatesh et al. (2003, 2012) explained how individuals adopt and use technology within a more comprehensive framework, *the unified theory of acceptance and use of technology* (UTAUT), through the dimensions *of performance expectancy, effort expectancy, social influence, and facilitating conditions*. We argue that UTAUT can provide a relevant foundation for explaining collective ambition, as its constructs—particularly social influence and performance expectancy—capture the convergence of individual perceptions into a shared understanding to form collective goals and coordinated actions within an organization. Based on this argument, we formulate the following research questions

- *RQ1*: How do collective ambitions and organizational commitment influence digital transformation and digital maturity for smart agriculture among smallholder farmers?
- *RQ2*: How does the integration of TAM and UTAUT explain the organizational-level digital transformation beyond the perspective of individual adoption?

We employed *partial least square structural equation modelling* (PLS-SEM) to address the research questions, drawing on data from 287 smallholder farmers across Indonesia, Malaysia, Thailand, Vietnam, and Cambodia. Building on this framework, we make two key theoretical contributions. First, this study applies the TAM at the organizational level to uncover smallholders' intentions to use and adopt smart agriculture, considering two key factors, PU and PEOU. Previous research has applied TAM at the individual level within higher education institutions (Lai et al., 2023), digital marketing (Wistedt, 2024), and hybrid work modelling (Naqshbandi et al., 2023; Petani & Mengis, 2023). In recent years, UTAUT has been widely applied in agriculture, including Internet of Things (IoT) (Ronaghi & Forouharfar, 2020), communication technology (Beza et al., 2018; Narine et al., 2019), and mobile applications (Michels et al., 2020). This study repositions

UTAUT as a determinant influencing organizational commitment and shifts the analytical focus from individual behavioral intentions to the sustainability and resilience of organizations within smart agriculture implementation.

The remainder of this study is structured as follows. Section 2 reviews the relevant literature and establishes the theoretical background. Section 3 presents the development of the research hypotheses and the research design. Section 4 describes the data sources, and SEM methodology. Section 5 presents the empirical results. Section 6 discusses the findings. Finally, Section 7 presents the global implications, conclusion, managerial and theoretical implications, limitations, and future research directions.

2. Literature Review

2.1. Technology Acceptance Model

Introduced by Davis (1989), the *Technology Acceptance Model* (TAM) is an adaptation of the *Theory of Reasoned Action* (TRA) and the *Theory of Planned Behavior* (TPB), specifically designed to model user acceptance of information systems. The TAM is the predominant framework for explaining how users adopt technology (Krithika & Rajini, 2016). This theory posits that an individual's acceptance of technology is predicted by their behavioural intention, which is primarily influenced by perceived ease of use and the technology's usefulness (Taylor & Todd, 1995). *Perceived usefulness* (PU) represents an individual's perception of the extent to which the utilization of a specific technology enhances performance (Davis, 1989). *Perceived ease of use* (PEOU) is the degree to which a person believes that using a particular system is effort-free (Davis, 1989). Alqatan et al., (2017); Awa et al., (2015), and Kala Kamdjoug et al., 2021) shown that TAM is a robust and widely used theory for explaining the adoption of new technologies by users. Agrarian studies have traditionally emphasized transitions as critical junctures of structural change that provide opportunities to digital transformation processes (Azadi et al., 2021; Banluesapy et al., 2026; Vishnoi & Goel, 2024), and alters the social dynamics within agrarian communities (Castella et al., 2023). Fragomeli et al., (2026) reinforces TAM framework in the agriculture, demonstrating that integrating sustainability (environmental, social, and economic), significantly influence farmers' intention to adopt 4.0 technologies. Other research has shown that a potential user's perception of a technology's usefulness in improving farm performance does not necessarily lead to its adoption (Sayruamyat & Nadee, 2020). This mediating role of attitudes underscores the complexity of the adoption process, in which farmers' evaluations of technology benefits must be translated into positive attitudes before influencing intentions. This aligns with prior evidence that adoption is impeded during the early stages due to uncertainty and limited understanding of the technology's benefits (Marescotti et al., 2021). Consistent with previous research, farmers do evaluate the potential consequences of their actions towards Agriculture 4.0, and the PU of these tools significantly influences their intention to adopt them (Ulhaq et al., 2022).

Additionally, Alexander et al. (2017) and Beban & Gironde (2023) have underlined the transformation of agrarian societies from agriculture-dependent systems to more industrialized and market-oriented modes of production. However, in contemporary SEA, agrarian transition is influenced by complex interactions among various factors, including land dynamics, advancements in agricultural technology, climate change, and diverse forms of structural transformation (Tran & Touch, 2024). The increasing integration of digital technology into agricultural practices has introduced a novel dimension to agrarian change, necessitating a more comprehensive understanding that transcends traditional economic and structural explanations. The TAM framework for technology adoption predominantly focuses on perceptions and decision-making at the individual level, thus offering a limited understanding of the collective and organizational dynamics characteristic of smallholder-based agricultural systems. Therefore, in this study, TAM is positioned as a theoretical lens to understand the factors influencing smart agriculture adoption in smallholders in SEA. Thus, the constructs in the research are contextualized at the organizational level, in accordance with the characteristics of smallholder farming systems that are collective and community-based.

2.2. Unified Theory of Acceptance and Use of Technology

UTAUT was proposed by Venkatesh et al., (2003) to analyze research on the adoption of information technology. Reviewing eight classical adoption theories (*the task-technology fit model, diffusion of innovation theory, theory of rational action, theory of planned action, technology adoption model, theory of planned action model, motivational model, and social cognitive theory*), they integrated the arguments and extracted four core constructs that affect willingness to adopt new technology: (1) performance expectation, the degree to which individuals expect to be helped by the use of the technology; (2) effort expectation, the level of effort required by individuals to use the technology; (3) social influence, the degree to which an individual's social environment affects their use of the technology; and (4) facilitating conditions, the degree to which the internal and external conditions of the individual's expected use of the technology promote their use of the technology. UTAUT is widely accepted in social research because of its explanatory power (up to 70%) (Venkatesh et al., 2003). In recent years, in the field of agriculture, UTAUT has been widely applied to IoT (Ronaghi & Forouharfar, 2020), communication technology (Beza et al., 2018; Narine et al., 2019), and mobile applications (Michels et al., 2020), among other areas of technology adoption intention research.

Despite the growing body of research on smart agriculture in SEA, existing studies provide limited insight into the collective dynamics and organizational structures that shape technology adoption among smallholder farmers (Parvathi & Waibel, 2016). This limitation is particularly important in ongoing agrarian transitions across the region. While agrarian transitions contribute to agricultural modernization and support adaptation to climate change and emerging development paradigms, their effects are often uneven across farming households (Tran & Touch, 2024). For instance, evidence from the Mekong Delta shows that even relatively better-off farmers, including landholders, face challenges in maintaining stable incomes due to volatility in rice markets (Betcherman et al., 2021). These conditions suggest that agricultural transformation, including digitalization, extends beyond the mere adoption of technology. Rather, it is closely associated with economic resilience, collective coordination, and the organizational capacity of farmers to respond to increasingly complex market and environmental challenges. Therefore, decisions regarding technology adoption are not solely individual choices but are shaped by social interactions, shared objectives, and coordinated actions within farming communities and organizations. To better understand these dynamics, this study employs the UTAUT as a theoretical framework for explaining technology adoption among smallholder farmers in SEA. Specifically, UTAUT provides a useful lens for examining how social and organizational factors influence the adoption of smart agriculture technologies within collective and community-based farming systems. The study seeks to explain how organizational commitment and collective ambition interact with technology acceptance processes to facilitate digital transformation and enhance digital maturity among smallholder farmers in Southeast Asia.

3. Hypotheses Development

3.1. Collective Ambition and Digital Transformation

Collective ambition offers a clear direction in environments characterized by sustained, large-scale, and accelerating changes. A shared vision and common objectives generate social energy that facilitates the acceptance of transformation at both the individual and collective levels (Ready & Truelove, 2011). Within organizations, collective ambition enhances interdependence among members and aligns their efforts toward a common purpose. Digital transformation inherently necessitates cross-functional collaboration, openness to innovation, and a willingness to challenge established routines, which are processes fundamentally driven by a shared sense of purpose. When organizational goals are coherently aligned through core elements, such as purpose, vision, strategic targets, and leadership behaviors, digital transformation transcends a purely technological initiative and becomes a profound organizational shift. In smart agriculture, digital transformation extends beyond the deployment of digital tools to encompass aligning strategic directions, objectives, and perceived technology values. This alignment is particularly critical in smallholder communities, where farming activities are highly interconnected and dependent on shared resources and coordinated actions. Collective ambition enables a unified and coordinated response to technological change, reduces fragmentation, and fosters collective engagement in digital initiatives.

Building on the *technology acceptance model* (TAM), we posit that individual perceptions of *perceived usefulness* (PU) and *perceived ease of use* (PEOU) form the cognitive basis for technology adoption (Davis, 1989; Venkatesh et al., 2003). When organizational members hold positive perceptions of technological benefits and usability, these individual assessments coalesce into collective beliefs about the strategic importance of digital technology. Through this collective sensemaking process, individual evaluations are transformed into shared aspirations that align digital adoption with organizational goals, such as enhanced productivity, resource efficiency, and climate resilience. Accordingly, collective ambition facilitates coordinated action and sustained digital transformation rather than isolated or sporadic technology use. Therefore, based on TAM, it is anticipated that collective ambition will influence digital transformation through shared perceptions of its usefulness and ease of use. The following hypothesis is proposed:
H1. Collective ambition has a positive influence on digital transformation.

3.2. Organizational Commitment and Digital Transformation

Digital transformation in smart agriculture transcends the mere adoption of digital technologies, encompassing changes in work practices, inter-actor collaboration, and continuous learning processes. Organizational commitment functions as a binding mechanism that aligns individual interests with the broader transformation agenda, thus mitigating resistance to change and enhancing the consistency of digital implementation processes. Smallholders who cultivate strong affective and normative attachments to their organizations or communities are more inclined to support digital initiatives and actively engage in transformation efforts (Hanelt et al., 2021; Wessel et al., 2021). Organizational commitment has long been a central construct in organizational psychology and management research; however, its role in digital transformation has only recently garnered scholarly attention (Naima et al., 2021). A previous study demonstrated that technological developments reshape affective commitment in altering how individuals form emotional bonds with organizations in the digital era (Melović et al., 2020). Empirical evidence further highlights the significance of organizational commitment across diverse digital transformation, including brand marketing and e-businesses (Melović et al., 2020) and sustainability principles (Najm et al., 2023). Research on SMEs during the COVID-19 pandemic also emphasizes that sustained organizational commitment is critical for navigating digital transformation amid uncertainty (Winarsih et al., 2021). These studies indicate that organizational commitment is a decisive factor in effective implementation and long-term sustainability of digital transformation initiatives. From the UTAUT perspective, we argue organizational commitment supports continued technology use by strengthening performance expectancy, reinforcing social influence, and enabling facilitating conditions. Accordingly, we propose the following hypothesis:
H2. Organizational commitment positively influences digital transformation.

3.3. Collective Ambitions and Digital Maturity

Digital maturity pertains to the degree to which digital technologies are systematically integrated, sustainably utilized, and strategically leveraged to enhance organizational processes, decision-making, and long-term operational capabilities. In contrast to digital transformation, which focuses on the process of change, digital maturity signifies an organization’s ability to consistently and purposefully exploit digital technologies over time, reflecting the stabilization and institutionalization of digital practices. From a socio-organizational perspective, this progression is not solely driven by technological adoption but also by shared cognitive and strategic alignment among organizational members (Blount and Leinwand, 2019). Collective ambition serves as a crucial social and cognitive foundation that facilitates the progression from digital transformation to advanced digital maturity. When organizational members, including smallholders, articulate explicit collective goals regarding the purpose and value of digital technologies, these shared beliefs function as a form of collective sensemaking that guides coordinated action and sustained engagement (Mian et al., 2025). As a result, digital practices are more likely to be institutionalized into daily routines rather than being perceived as temporary initiatives, promoting consistency in the development of digital capabilities, the use of data-driven decision-making, and collaboration among actors within the smart agriculture ecosystem. This perspective is further supported by prior studies emphasizing the importance of shared goals, collaboration, and organizational alignment in shaping digital maturity (Foguesatto et al., 2024; Mian et al., 2025). Inter-organizational collaboration and alignment around common objectives reduce fragmentation and enhance coordination, whereas knowledge-sharing routines and complementary resources contribute to sustained capability development, particularly in resource-constrained environments. Moreover, digital maturity is closely associated with dynamic capabilities, such as adaptability, continuous learning, and resource reconfiguration, all of which depend on a shared orientation toward long-term goals (Jie et al., 2025). In this regard, collective ambition acts as a unifying mechanism that aligns cognition, action, and organizational direction, enabling organizations to continuously assess, refine, and advance their digital capabilities while supporting the routinization of digital practices over time. Accordingly, this study proposes the following hypothesis:
H3. Collective ambition positively influences digital maturity.

3.4. Organizational Commitment and Digital Maturity

Organizational commitment, which denotes individuals' psychological attachment to and investment inorganizations, is pivotal in decision-making processes and successful adaptation to digital change. Najm et al. (2023) contend that digital transformation serves as a mediating mechanism between sustainability principles and organizational commitment, highlighting that digitalization transcends mere technical processes by reshaping individual attitudes, identities, and organizational affiliations. Meanwhile, maturity signifies optimal conditions, serving as an indicator of achievement and a framework for addressing or preventing issues (Nikkhou et al., 2016). The maturity model offers a comprehensive understanding of a company's status and the necessary steps to implement an Industry 4.0 strategy (Akdil et al., 2018). Maturity serves as a criterion for evaluation and beneficial for establishing the foundational phase, leading to a more advanced final phase (Proença and Borbinha, 2016). Digital maturity signifies an advanced stage of digital transformation in which technologies are deeply integrated into organizational structures, cultures, and routines, facilitating improved work organization, streamlined processes, and the application of data-driven decision-making and advanced analytical models (Rahman, 2025). These conditions enhance collaboration, strengthen alignment with shared organizational objectives, and reinforce long-term commitment to sustainability. Herscovitch and Meyer (2002) demonstrated that individuals with high levels of organizational commitment are more proactive in problem solving and contribute more positively to organizational performance. From a socio-technical perspective, organizational commitment facilitates the integration of human and technological elements by fostering loyalty, a sense of responsibility, and a willingness to learn and adapt continuously. This construct is also conceptually aligned with the UTAUT, which posits that performance expectancy, effort expectancy, social influence, and facilitating conditions support sustained technology use. When smallholders develop strong affective and normative attachments to their organizations, they are better positioned to leverage institutional support, maintain digital practices, and progressively strengthen their digital capabilities. Consequently, organizational commitment is conceptualized as a key driver of achieving higher and more sustainable levels of digital maturity. Based on the above argument, the following hypothesis is proposed:

H4. Organizational commitment positively influences digital maturity.

To establish a theoretical foundation, a conceptual framework was developed to capture the relationships between key technology acceptance constructs and digital capability outcomes. The proposed model, presented in Figure 2, delineates the hypothesized organizational factors of digital transformation and digital maturity.

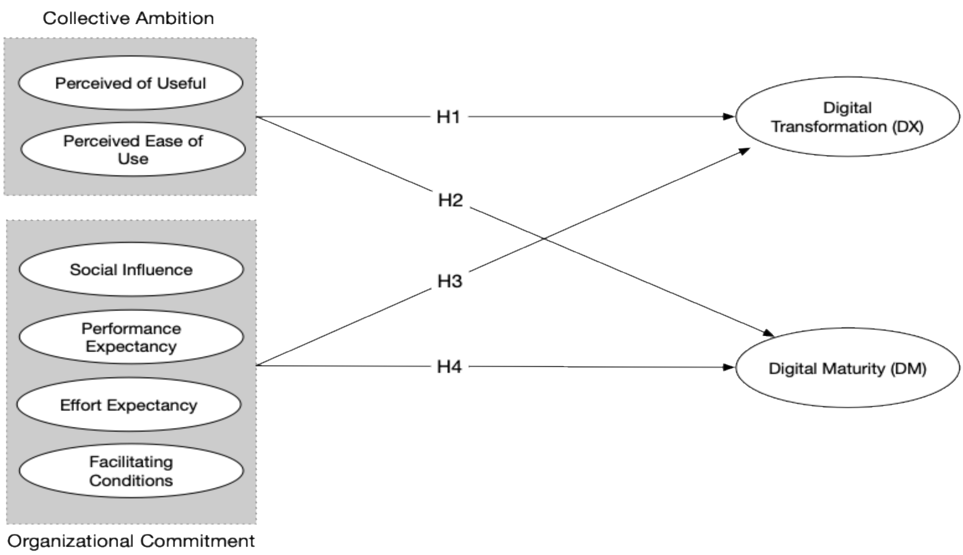

Figure 1. Proposed Conceptual Framework

4. Methodology

This study was conducted in the SEA region between August and September 2025 through field surveys in agricultural areas in Indonesia, Malaysia, Thailand, Vietnam, and Cambodia. The SEA region contributes to approximately 49.7% of Asia's total population (Population Reference Bureau, 2025). The region's food production systems are vital to regional and global food security. From 2011 to 2022, the region exported nearly 519 million metric tons of rice produced from its paddies, accounting for over a quarter of the world's production of rice (FAO, 2023). Mixed farming systems are the traditional form of rural livelihood in SEA and are still practiced by a large number of the estimated 100 million smallholders in the region (Tan & Kuebbing, 2023). Attempting to cover the entire population in this study would be tedious owing to time and budget constraints; therefore, G-Power version 3.1 was utilized in the selection of an appropriate sample size. G-Power software recommended a sample size of 215 to test the proposed research model with an effect size of $f^2 = 0.05$, $\alpha = 0.05$, power = 0.95, and two predictors. The PLS-SEM, on the other hand, required a minimum sample size of 100 (Reinartz et al., 2009). Participants were recruited using *purposive* and *snowball sampling*, covering 15 agricultural zones and involving approximately 35 respondents from each zone. A total of 525 questionnaires were distributed and collected, of which 287 were deemed valid, resulting in a response rate of 54.5%. The distribution of valid respondents is as follows: Indonesia (102), Malaysia (54), Thailand (51), Vietnam (47), and Cambodia (33), ensuring balanced representation across the region.

Survey questionnaires were employed to collect data from the study area. The distribution process was facilitated through farmers' cooperatives, agricultural extension officers, and local non-governmental organizations involved in digital agriculture initiatives. The questionnaire comprised two sections. The first section gathered information on respondents' demographic characteristics, including digital transformation readiness, age, education, annual income, cultivated land area, and land tenure status. The second section measured the study constructs, namely collective ambition, organizational commitment, digital transformation, and digital maturity. All measurement items were adapted from established scales reported in previous studies (see Appendix A). Responses were assessed using a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

4.1. Data Analysis

A *structural equation model* (SEM) was employed to examine the relationships among collective ambition, organizational commitment, digital transformation, and digital maturity among smallholder farmers. Owing to the complexity of the developed model, which includes multiple latent constructs, the *partial least squares-based* method (PLS-SEM) was chosen instead of *covariance-based structural equation modelling* (CB-SEM). PLS-SEM consists of two main components. The first component is the measurement model, referred to as the outer model. The outer model estimates the contribution of each indicator in representing its associated latent variable and assesses how well the combined set of indicators measures a construct. The second component is the structural model, referred to as the inner model. The inner model measures the direct and indirect relationships between latent variables (Hair et al., 2014).

4.2. Assessment of Measurement Model

Measurement model test revealed lower and higher factor loading values of 0.695 and 0.859, respectively (Table 1), indicating satisfactory internal consistency. As recommended by Gudergan et al. (2008), a factor loading greater than 0.70 is best for reliability assessment; however, if the AVE does not attain a satisfactory level, a value between 0.40 and 0.70 may be omitted. Hence, no item was dropped, as our AVE result attained the suggested cut off point of 0.50 (Hair et al., 2016).

Construct		**Items of the construct**	**Outer Loadings**
Collective ambitions	CA1	Clear understanding of organizational goals	0,785
	CA2	Organizational vision provides clear direction for digital transformation	0,766
	CA3	Realistic targets for sustainable digital transformation	0,761
	CA4	Strategic priorities align with shared vision	0,785
	CA5	Commitment to stakeholder promises	0,704
	CA6	Organizational values guide actions	0,783
	CA7	Leadership behavior aligns with vision and values	0,718
Organizational commitment	OC1	Strong sense of belonging to organization	0,786
	OC2	Commitment to improving digital maturity	0,812
	OC3	Participation in digital transformation is meaningful	0,815
	OC4	Responsibility toward digital transformation challenges	0,774
Digital transformation	DX1	Farming activities digitally connected with stakeholders	0,859
	DX2	Digitalization across farming activities	0,825
	DX3	Digital integration from production to distribution	0,785
	DX4	Use of digital tools for marketing	0,800
	DX5	Use of digital tools for transactions	0,803

Digital maturity	DM1	Digital systems are safe and accessible	0,701
	DM2	Ability to integrate and use agricultural data	0,695
	DM3	Support through training and digital literacy	0,719
	DM4	Collaboration in digital farming practices	0,787
	DM5	Use of digital systems to improve efficiency	0,774

Table 1. Outer Loadings of the Measurement Model

The measurement model also reveals convergent and discriminant validity following Fornell–*Larcker's* criterion and *the Heterotrait–Monotrait Ratio* (HTMT). Convergent validity is the degree to which indicators of a specific construct converge or share a high proportion of variance in common (Hair et al., 2016). The findings indicate that the *composite reliability* (CR) ranged between 0.773 and 0.882, while the AVE ranged between 0.515 and 0.663, both of which exceeded the cut-off point of 0.50 (Hair et al., 2010) and satisfied the convergent validity. To determine construct reliability and internal consistency, a cut-off point above 0.70 was considered for evaluating rhoA and *Cronbach's alpha* (Dijkstra & Henseler, 2015). In our study, the rhoA threshold ranged from 0.773 to 0.882, indicating a satisfactory level of construct reliability. Cronbach's alpha for this study exceeded the threshold of 0.70, indicating internal consistency of the data. Table 2 presents the summarized results of the construct reliability and validity.

Constructs	**Cronbach's Alpha**	**Rho_A**	**Composite Reliability**	**AVE**
Collective ambitions	0,877	0.882	0,882	0,574
Organizational commitment	0,809	0.773	0,814	0,635
Digital transformation	0,873	0.878	0,878	0,663
Digital maturity	0,765	0.814	0,773	0,515

Table 2. Construct Reliability and Validity

Discriminant validity was assessed by differentiating the square root of the AVE and factor correlation coefficients. In this study, three methods were used to verify discriminant validity. Table 3 presents the results of the Fornell–Larcker criterion for discriminant validity. Fornell & Larcker (1981) stated that the average variance shared between each construct and its measurements should exceed the variance shared between the construct and other constructs. The findings revealed that each variable conforms to a satisfactory level of discriminant validity. This is because there is no correlation (shown off-diagonal) exceeding the square root of the AVE (shown diagonal), subsequently indicating the validity of all constructs according to the discriminant validity test by Fornell and Larcker (1981).

	Collective Ambition	**Digital Maturity**	**Digital Transformation**	**Organizational Commitment**
Collective Ambition	**0,758**			
Digital Maturity	0,402	**0,717**		
Digital Transformation	0,409	0,476	**0,815**	
Organizational Commitment	0,380	0,337	0,425	**0,797**

Note(s) **:** The square root of AVE is presented in diagonals and correlations, off-diagonals

Table 3. Discriminant Validity

Second, cross-factor loadings were examined to determine the discriminant validity of the measurement model. Table 4 presents the results of the cross-factor loadings. Hair et al. (2016) suggested that all indicators must have higher loadings for their respective variables. The results showed that all indicators had the highest values for their respective constructs, ensuring the attainment of discriminant validity in the existing study. Third, to accurately ascertain discriminant validity, the *heterotrait–monotrait* ratio (HTMT) was determined. An HTMT value lower than 0.85–0.90 is considered satisfactory discriminant validity (Gold et al., 2001; Henseler et al., 2015; Kline, 2023). The findings indicated that all HTMT values of correlations had values below 0.90, confirming satisfactory discriminant validity for all variables (Table 5).

Item	Collective Ambition	Digital Maturity	Digital Transformation	Organizational Commitment
CA1	0.785	0.310	0.336	0.355
CA2	0.766	0.372	0.313	0.276
CA3	0.761	0.305	0.338	0.303
CA4	0.785	0.258	0.314	0.339
CA5	0.704	0.226	0.276	0.160
CA6	0.783	0.364	0.333	0.297
CA7	0.718	0.263	0.243	0.267
DM1	0.244	0.701	0.264	0.217
DM2	0.280	0.695	0.314	0.194
DM3	0.309	0.719	0.321	0.271
DM4	0.331	0.787	0.394	0.300
DM5	0.265	0.680	0.408	0.208
DX1	0.391	0.418	0.859	0.382
DX2	0.373	0.395	0.825	0.325
DX3	0.336	0.359	0.785	0.336
DX4	0.285	0.393	0.800	0.315
DX5	0.266	0.370	0.803	0.371
OC1	0.314	0.276	0.316	0.786
OC2	0.286	0.273	0.319	0.812
OC3	0.359	0.296	0.392	0.815
OC4	0.241	0.222	0.319	0.774

Table 4. Cross Loadings

Variables	Collective Ambition	Digital Maturity	Digital Transformation	Organizational Commitment
Collective Ambition	-			
Digital Maturity	0.479	-		
Digital Transformation	0.460	0.579	-	
Organizational Commitment	0.442	0.419	0.501	-

Table 5. Heteroit-Monotrait Ratio (HTMT)

5. Empirical Results

5.1. Respondents' Socio-Demographic Profile

As shown in Table 6, 78.4% of smallholders indicated a willingness to engage in digital agricultural transformation. The mean age of the respondents was 46 years, with the predominant age group being 40–50 years (39.6%). Most smallholders had a lower secondary education background, with 8.2% having completed only primary school or not attending school at all and 52.7% having dropped out of junior high school. Nonetheless, 17.5% of the respondents had attained higher education. The average annual income of agricultural households was $3,500, with 14.3% earning over $6,000 per year. The average arable land area was 1.8 ha, and 51.2% of the smallholders had less than 1 ha. Land ownership was diverse, comprising 65.4% rice fields, 28.6% dry land, and 6.0% a combination of both.

Characteristic	Percentage (%)	n
Digital Transformation Readiness		
Willing to get involved	78.4	225
Unprepared	21.6	62
Age		
Average age (years)	46	-
40–50 years	39.6	114
Education		
Elementary school or not in school	8.2	24
Junior	52.7	151

High School/Diploma	21.6	62
College	17.5	50
Household Income per Year		
Average (USD)	3,500	-
> 6,000 USD	14.3	41
≤ 6,000 USD	85.7	246
Cultivated Land Area		
Average (ha)	1.8	-
< 1 ha	51.2	147
≥ 1 ha	48.8	140
Land Type		
Paddy	65.4	188
Dry land	28.6	82
Rice fields and dry land	6	17

Table 6. Respondents' Socio Demographic Information

5.2. Structural Model Evaluation

To assess potential collinearity issues within the structural model, the variance inflation factor (VIF) was examined. VIF values are commonly used to detect multicollinearity among predictor variables, which may distort model estimates and significance levels. Hair (2011) suggested that collinearity issues may arise when VIF values exceed 5.0, whereas Diamantopoulos & Siguaw (2006) recommended a more conservative threshold of 3.3. The results indicated that all VIF values ranged from 1.358 to 2.292, remaining well below the recommended thresholds and suggesting the absence of multicollinearity concerns (Hair et al., 2010). The predictive accuracy of the model was subsequently evaluated using the coefficient of determination (R^2), which represents the proportion of variance explained by the exogenous constructs. The results showed that the R^2 values for digital transformation and digital maturity were 0.252 and 0.201, respectively. These findings indicate that collective ambition and organizational commitment explain 25.2% of the variance in digital transformation and 20.1% of the variance in digital maturity (Wetzels et al., 2009).

The results indicate that collective ambitions have a significant positive effect on digital transformation ($\beta = 0.289$, $t = 5.827$), supporting H1. Similarly, organizational commitment significantly influences digital transformation ($\beta = 0.315$, $t = 6.203$), supporting H2. Furthermore, collective ambitions significantly affect digital maturity ($\beta = 0.320$, $t = 5.767$), and organizational commitment also has a significant effect on digital maturity ($\beta = 0.215$, $t = 3.854$), thus supporting H3 and H4 (Table 7). Figure 2 illustrates the results of the structural model assessment.

The *F*-square (f^2) values were computed using the effect size with *R-squared* (R^2). An *F*-square value of 0.35 reflects a high effect size, whereas 0.15 and 0.02 are considered medium and small effect sizes, respectively (Cohen, 1988). As shown in Table 7, the *F*-square value of the collective ambition for digital transformation (0.110) is considered small-medium, organizational commitment to digital transformation (0.096) is considered small, collective ambition for digital maturity (0.050) is considered small, and organizational commitment to digital maturity (0.114) is considered small-medium.

Hypo	**Path Relation**	**β**	**St. Deviation**	**t-value**	**f^2**	**Comment**
H1	CA → DX	0.289	0.050	5.827	0.110	Accepted
H2	OC → DX	0.315	0.051	6.203	0.096	Accepted
H3	CA → DM	0.320	0.055	5.767	0.050	Accepted
H4	OC → DM	0.215	0.056	3.854	0.114	Accepted

Table 7. Results of Direct Effects among Constructs

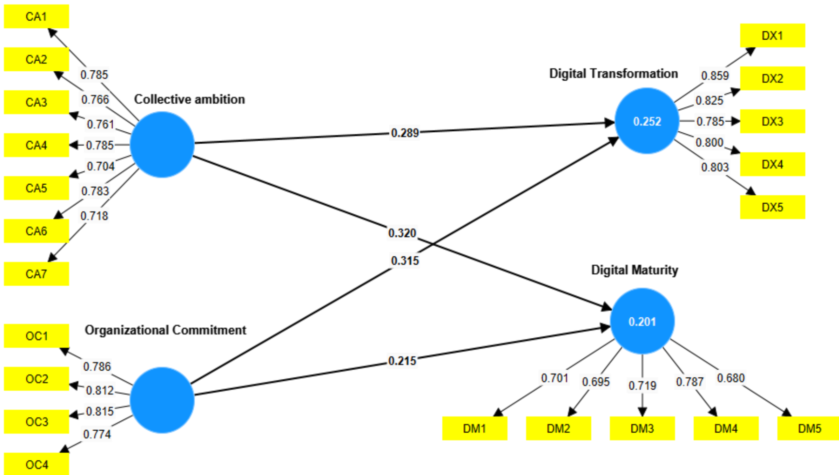

Figure 2. Structural Model Results from SEM-PLS Analysis

6. Discussion

This study represents one of the pioneering in the academic literature, a comprehensive evaluation of collective ambition in digital transformation within smart agriculture, specifically for smallholder farmers. Additionally, this research offers preliminary insights into the potential for achieving long-term objectives of digital technology at the community farming level. Beyond its findings, the study proposes a set of indicators designed to assess the integrity of the processes involved in forming and planning collective ambition for the adoption of digital technology.

Our initial findings indicate that collective ambition significantly impacts the digital transformation of smart agriculture among smallholders in SEA. There is a shared commitment to adopting digital technologies to enhance agricultural productivity, efficiency, and sustainability. The TAM framework elucidates technology acceptance through two primary constructs: PU and PEOU. For instance, if a farming community perceives that digital technology will improve crop yields (*perceived usefulness*), collective ambition will facilitate faster adoption. Furthermore, if the technology is deemed user-friendly, collective ambition encourages motivation to disseminate knowledge and provide mutual support (*perceived ease of use*). IoT technologies bring substantial benefits to farmers and agricultural businesses, includeing increased productivity, efficiency, cost reduction, and improved decision-making processes. Through IoT utilization, farmers can automate monitoring systems, employ sensors and actuators, and incorporate cloud-based technologies for data analysis and decision-making (Lova Raju & Vijayaraghavan, 2022). IoT acceptance in agriculture, industry influence refers to the impact and role that key stakeholders within the farming community and society have on individuals' decision-making processes (Yang et al., 2022). These influential figures include experienced agro-entrepreneurs, prominent members of the agricultural sector, and individuals who hold significance in a person's life and decision-making processes.

Our second finding indicates that organizational commitment positively influences digital transformation. *Effort expectancy* emerged as notable dimensions farmers' engagement with digitalization initiatives (OC3; *mean* = 4.20). *Social influence* significantly impacts the sense of belonging within the organization, thus accelerating adoption with group norms (OC1; *mean* = 4.15). *Facilitating conditions* represent the weakest dimension, that institutional and structural support mechanisms are insufficient to fully support long-term digital transformation (OC4; *mean* = 4.02). These findings are consistent with Ali et al. (2020) and Ulhaq et al., (2022) which emphasizes attitudes towards technology in influential farmers' adoption behavior. Sen et al. (2024) focus on behavioural factors, including subjective norms, beliefs, risk perceptions, and attitudes toward utility, which predominantly influence technology adoption in Cambodia, the Philippines, and Vietnam. Our findings confirm that individual behavioral characteristics and farmers' emotional attachment to their organizations are key factors in accelerating digital transformation. Organizational commitment is crucial for facilitating digital transformation in farmers' psychological readiness, strengthening their sense of behavioural control, and fostering trust in the long-term benefits of digital technology. When smallholder farmers possess a deep emotional attachment and identification with their organization, they exhibit greater confidence in the benefits of technology (*performance expectancy*), feel more competent in its use (*effort expectancy*), are more responsive to collective influence (*social influence*), and optimize structural support (*facilitating conditions*).

The third finding highlights collective ambition in driving digital maturity, particularly through perceptions related to usefulness. Digital maturity is achieved when technology is viewed as a practical tool for realizing an organization's long-term objectives. Collective ambition serves as a strategic guide, aligning smallholder farmers with organizational management on digital transformation goals. This ensures consistency in the development of digital capabilities, readiness to adopt smart agriculture technologies, and drives innovation in agricultural production and management processes. According to Roeven et al., (2025), collective ambition serves as a shared vision and a platform for continuous learning. This facilitates the harmonization of understanding, the negotiation of differences, and the gradual enhancement of digital capacity among participants. Organisational managers had a role in improving digital literacy, expanding technological knowledge (e.g. soil sensors, crop monitoring software, and data management systems), and integrating technology into routine operational tasks. Because food communities must reconcile diverse perspectives and practical needs, smallholder farmers in SEA face similar dynamics when implementing collective digital ambitions. Without systematic learning mechanisms, collective visions risk becoming merely statements of intent rather than processes of continuous development.

The fourth finding indicates that organizational commitment exerts a positive influence on digital maturity, with relevant factors of effort expectancy and performance expectancy. A willingness to learn and confidence in one's ability to increase performance are essential for attaining digital maturity. Robust organizational commitment facilitates the effective integration of human and technological elements in SEA smart agriculture practices. From a socio-technical perspective, organizational commitment develops coherence, loyalty, and psychological readiness of smallholder farmers to adopt digital practices in agricultural activities (Paul et al., 2022). Smallholder farmers who possess an emotional attachment to and alignment with organizational goals are more likely to adopt new technologies, engage in training, and consistently utilize digital systems. Taghibaygi & Alibaygi (2024) investigated organizational ethical commitment toward digital integration and found that effectiveness positively influences ethical norms, which subsequently affect farmers' intentions to employ digital technology in agriculture in Iran. Farmers who perceive that digital agricultural technology enhances food security are more motivated to adopt it. Enhancing farmers' understanding of food security challenges and the significance of collaborative efforts can strengthen their ethical commitment to digital technology. Given that farmers rate training programs as effective, implementing educational initiatives, such as digital agriculture courses, demonstration farms, dialogues with landowners, and direct observation of the tangible outcomes of digital technology, could be a key strategy to bolster farmers' ethical commitment to the broader adoption of digital technology.

7. Conclusion

This study reveals collective ambition and organizational commitment to digital transformation and digital maturity among smallholder farmers in smart agriculture in SEA. Our initial finding indicates that collective ambition significantly impacts the digital transformation of smart agriculture among smallholders in SEA. The TAM framework elucidates technology acceptance through two primary constructs, PU and PEOU. Second, organizational commitment influences digital transformation. Our findings confirm that individual behavioral characteristics and farmers' emotional attachment to their organizations are key factors in accelerating digital transformation. Organizational commitment is crucial in facilitating digital transformation in farmers' psychological readiness, strengthening their sense of behavioral control, and fostering trust in the long-term benefits of digital technology. Third, collective ambition drives digital maturity, particularly through the dominant PU dimension. Collective ambition serves as a strategic guide, aligning smallholder farmers with organizational management on digital transformation goals. This ensures consistency in the development of digital capabilities, readiness to adopt smart agriculture technologies, and drives innovation in agricultural production and management processes. The fourth finding indicates that organizational commitment exerts a positive influence on digital maturity, with effort expectancy and performance expectancy serving as fundamental determinants. A willingness to learn and confidence in one's ability to increase performance are essential for attaining digital maturity. Robust organizational commitment facilitates the effective integration of human and technological elements in smart agriculture practices in SEA.

7.1. Managerial Implications

This study makes a significant contribution by introducing a novel conceptual framework for comprehending institutionally driven digital transformation in agriculture. Although the framework is rooted in SEA, it also applies to other developing regions that exhibit similar social, institutional, and structural characteristics. The findings provide crucial managerial and policy-relevant insights for key stakeholders, including farmers, agricultural cooperatives, non-governmental organizations, and public institutions. Promoting a digitally oriented organizational commitment requires, foremost, articulating a clear digital vision and cultivating an organizational culture that values innovation and continuous learning. Leso et al. (2023) concluded that the results emphasize culture, organizational arrangements, and leadership in digital transformation, addressing earlier theoretical calls for the importance of strategic orientation in digitalization. This study advances the practice of smallholder groups to establish structured platforms for collective deliberation and coordination concerning digital transformation goals. Cooreman et al. (2021) argued that on-farm demonstrations can serve as effective learning spaces that support transformative learning when combined with facilitated dialogue and participatory approaches. The impact of such demonstrations is largely contingent upon their relevance to smallholders' real-world conditions and their capacity to integrate hands-on experience. Embedding knowledge exchange within field demonstrations enhances learning outcomes with stimulating critical reflection, constructive cognitive tension, and deeper knowledge sharing, compared to demonstrations that lack intentional dialogical facilitation. Furthermore, given that most smallholders remain at an intermediate stage of digital maturity, organizational leadership must proactively identify and address the key constraints that impede the complete adoption and effective utilization of digital technologies. An important, often under emphasized strategy is to integrate climate-related indigenous knowledge systems into the development and promotion of smart agriculture practices. Ewulo et al. (2025) suggested this integration can be achieved through participatory workshops and community-based consultations that recognize, value, and incorporate local knowledge and perspectives. Additionally, given smallholders' propensity to adopt smart farming practices in a bundled rather than isolated manner, agricultural extension services should advocate for integrated smart agriculture packages tailored to specific agroecological zones and farming systems. Such an approach can more effectively support the progression of digital maturity while enhancing the long-term sustainability and resilience of the agricultural sector.

7.2. Theoretical Contributions

The existing literature has extensively examined digital technology within the agricultural sector, focusing primarily on the following central themes: (1) the role and benefits of smart agriculture (Choruma et al., 2024; Hoang & Tran, 2023), (2) the factors influencing its adoption (Dibbern et al., 2024; Smidt & Jokonya, 2022), and (3) TAM and UTAUT adoption are conventionally employed to elucidate technology adoption at the individual level. However, studies have not fully elucidated the collective dynamics that define smallholder-based agricultural systems, particularly in SEA.

This study introduces the organizational dimension of collective ambition as a key antecedent of digital transformation and integrates it with the TAM to capture the social dynamics underlying technology adoption. Collective ambition is identified as a factor shaping the perception of usefulness and ease of use, as strong collective aspirations align the vision, goals, and beliefs of organizational members, thus increasing trust in ease of digital technology adoption. The TAM dimensions, PU and PEOU, elucidate the significance of collective ambition for digital transformation and digital maturity. The PU factor exerts a greater influence than PEOU, as smallholder farmers develop collective ambitions based on the belief that technology is advantageous for achieving the organization's long-term objectives. Meanwhile, PEOU serves as a supporting factor that facilitates technology adoption through ease of use and perceived value once its strategic advantages are collectively acknowledged. This study also contributes theoretically to the UTAUT framework through its integration with organizational commitment. Social influence and business expectations have emerged as the primary determinants of organizational commitment to digital transformation. Strong social influence reflects a robust social identity and collective norms within the farmer group, while business expectations suggest that digital transformation is perceived as a significant yet realistic endeavour. The key consistency across all these aspects lies in the cumulative ability to reduce uncertainty, anxiety, and resistance to change by affirming value, ease, social support, and organizational readiness to adopt technology. Ultimately, these variables integrate individual perspectives into collective commitment and behaviour that drive digital transformation and sustainable digital maturity. In accordance with Smidt & Jokonya (2022) to investigate the impact of digital technology adoption on the lives of rural communities, including aspects such as work patterns, social interactions, and access to information, to evaluate the genuine engagement of smallholder farmers.

Our research aims to emphasise the collective and organizational dimensions of digital transformation. To achieve this, the study integrates the TAM and UTAUT constructs with observational variables that reflect agricultural digitalization practices, such as the connectivity of farming businesses with stakeholders (DX1), integration of production processes through distribution (DX3), and utilization of digital technology for transactions and promotion of agricultural produce (DX4–DX5). Additionally, the level of digital maturity was evaluated using indicators that assess system security, data integration capabilities, digital literacy support, external collaboration, and farm efficiency (DM1–DM5). The SEA region exhibits a significant gap in empirical and qualitative research on the adoption rates of smart farming services and technologies. Our study contributes empirical evidence from a psychological-organizational perspective, reinforcing the findings of Musa & Basir (2021), who suggested that smart farming possesses substantial potential to sustainably enhance food production while maintaining rigorous standards of food safety and quality. This approach offers a promising avenue towards achieving Sustainable Development Goal 2 (*Zero Hunger*) using innovative methods to construct food systems that are more profitable, resilient, and environmentally sustainable. For example, this entails aligning technological progress with best practices from countries that have further experience in smart farming, particularly concerning the adaptation of technology to each nation's specific climatic conditions. These elements are operationalized through the constructs of digital transformation (e.g., connectivity between farming enterprises and stakeholders, integration of processes from production to distribution, and the utilization of digital technology for transactions and the promotion of agricultural products) and digital maturity (e.g., system security, data integration capabilities, support for digital literacy, external collaboration, and the efficiency of farming businesses).

7.3. Global Practice Implications

7.3.1. Youth Participation and STEM Learning

To establish a functional ecosystem for smart farming in SEA, more robust foundational strengths are imperative. At the grassroots level, particularly in less developed member states, skill deficiencies exist, notably in language and digital literacy (Hoang & Tran, 2023; Thi Hoa Sen et al., 2024). These barriers significantly impede rural farmers from adopting new technologies that can streamline and enhance their agricultural practices. Similar challenges have been observed in other countries, including developed regions, where most farmers are elderly. Therefore, training and capacity-building initiatives are essential to overcome entry barriers for young farmers, including access to markets, financing, and necessary inputs or equipment (Musa & Basir, 2021). Fundamentally, the government can support *science, technology, engineering, and mathematics* (STEM) education to cultivate interest among the younger generation in agriculture for technological disruption. A pertinent example is the green education system in the Netherlands (Kupper et al., 2012) and Australia (Gough et al., 2024), which has positively contributed to the development of high-quality human resources in the green sector (agriculture, nature, food). Similar initiatives could be considered globally, including in SEA, to develop a workforce capable of addressing the challenges of sustainable agriculture.

7.3.2. Institutional Framework and Regional Cooperation

The government is crucial for establishing a framework for the adoption of new technologies in the agricultural sector. Close coordination between ministries is required to ensure that agricultural policies are relevant, effective, and inclusive. Given the accelerating pace of technological disruptions, policymakers must be adaptable and responsive to ever-changing technological interventions. In addition to labor and technology, significant investments are still required for research and development of products and smart farming solutions. The agri-finance subsector also needs to be encouraged without excessive regulation to create an ecosystem that supports digital agricultural innovation. Building a robust smart farming ecosystem is not limited to national efforts alone. The government, research institutions, and industry leaders must collaborate to facilitate the research and development of digital agricultural solutions. Disruptions in the food supply chain caused by the COVID-19 pandemic serve as a stark reminder of the risks that can arise if food systems and trade are disrupted. Given that none of the 10 ASEAN member states are self-sufficient in food production and that there is a high degree of intercountry dependence for food supplies (Lai, 2020), the adoption of smart farming technology must be undertaken collectively. In comparison, the European Union's *Common Agricultural Policy* (CAP) has long protected Europe's agricultural sector. This policy is one of the most integrated and absorbs approximately 40% of the EU budget to support the food production environment and farmers' incomes (Pe'er et al., 2019). Although ASEAN lacks a similar mechanism, it can still develop regional cooperation to intensify food security agendas. Macro-level strategies, such as the ASEAN *Food Security Reserve*, which sets aside and shares rice reserves during contingencies, as well as the ASEAN *Integrated Food Security* (AIFS) *Framework and the Strategic Plan of Action on ASEAN Food Security* (SPA-FS), have become important platforms for information exchange, the transfer of new technologies, and knowledge sharing.

7.4. Limitations & Future Reseach Agenda

The primary limitation of this study is that it focused on smallholders in SEA, which may limit the applicability of the findings to agricultural studies in other regions. Although the study offers valuable insights into technology adoption, the results may not be generalizable to the broader agricultural sector because of variations in organizational environments, resource capabilities, and regulatory conditions. Additionally, the research achieved a response rate of 54.5%, which, although sufficient for SEM, may introduce potential non-response bias. Despite statistical tests indicating no significant bias, caution is advised when interpreting the generalizability of the findings. Future research could enhance external validity by incorporating a more extensive and diverse sample from various regions or smallholder stakeholder groups, such as agritech start-ups, the food processing industry, microfinance institutions, ministries of agriculture, and cross-regional bodies, and local communities and farmers' social networks. Moreover, the rapid advancement of technologies, such as artificial intelligence and blockchain, underscores the necessity for ongoing analysis of their adoption processes. Future research could assess the impact of these technologies on operational efficiency, strategic alignment, and competitive advantage, thereby providing actionable insights for organizations undergoing digital transformation. Although the proposed model explains important aspects of digital transformation and digital maturity among smallholders in SEA, additional organizational, technological, and contextual factors may further explain the variance in these constructs. Factors such as leadership, digital infrastructure, government support, socio-economic conditions, and technological readiness were not explicitly examined in this study and may provide valuable directions for future research. This approach will help ensure that the research remains pertinent to the practical and strategic needs of businesses in a rapidly evolving digital environment. As digital technology progresses, new studies must also investigate critical areas, such as cybersecurity, data privacy, and talent development. These aspects are crucial because they represent both the primary challenges and opportunities within the digital transformation landscape. Further research should focus on how organizations design strategies to manage these challenges while preparing their workforce to meet the demands of ever-evolving technology.

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Appendix 1. Measurement Items

Latent Variable	Theory Integration		Observational Variable	Category Coding
Collective ambitions (Ready & Truelove, 2011)	Technology Acceptance Model	Perceived Usefulness	I clearly understand our organization's key goals and believe they are important for the future.	CA1
			I believe our organization's vision provides a clear direction towards digital transformation.	CA2
			Our organization has realistic targets and benchmarks to achieve sustainable digital transformation.	CA3
			I see that our organization's strategic and operational priorities consistently support the achievement of a shared vision	CA4
		Perceived Ease of Use	Our organization is committed to delivering on its promises to stakeholders (smallholders, communities, investors, and partners) regarding the experience and benefits they have been promised.	CA5
			I feel that the core values of our organization are a real guide in facing challenges and successes.	CA6
			Our organizational leaders demonstrate day-to-day behaviors that are consistent with the organization's vision, values, and commitments.	CA7
Organizational commitment (Meyer & Allen, 2001)	Unified Theory of Acceptance and Use of Technology	Social Influence	I have a strong sense of belonging to this smallholder organization, especially in our joint efforts to achieve digital transformation.	OC1
		Performance Expectancy	I feel tied to my smallholder organization and am committed to supporting the increase of digital maturity.	OC2
		Effort Expectancy	Participating in the agricultural digital transformation program at this organisation means a lot to me.	OC3
		Facilitating Conditions	I feel that the challenges that organizations face in the digital transformation process are also my responsibility.	OC4
Digital transformation (Zahoor et al., 2023)			My farming business is increasingly digitally connected with stakeholders.	DX1
			The digital transformation of agriculture is increasingly penetrating and connecting various aspects of my farming activities.	DX2
			My farming process, from production to distribution, is increasingly digitally integrated.	DX3
			I use digital technology to promote agricultural produce and reach buyers.	DX4
			I use digital technology to support farming transactions.	DX5

Digital maturity (Deloitte, 2018)	I feel that the digital systems I use in agriculture are safe and accessible.	DM1
	I can integrate and leverage agricultural data to support my farming decisions.	DM2
	I received support through training, mentoring, or digital literacy programs that improved my ability to use digital farming technology.	DM3
	I collaborate with external stakeholders in developing digital farming practices.	DM4
	I use digital systems to improve efficiency in my farming business.	DM5