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Digitalisation of Agriculture and Food Systems in ASEAN: A Preliminary Assessment for Enhanced Resilience and Sustainability

Economic Research Institute for ASEAN and East Asia

Digitalisation of Agriculture and Food Systems in ASEAN: A Preliminary Assessment for Enhanced Resilience and Sustainability

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Preface

The Association of Southeast Asian Nations (ASEAN) is undergoing a profound digital transformation that is reshaping economies, industries, and societies. Across sectors, digital technologies are creating new opportunities to enhance productivity, improve efficiency, strengthen connectivity, and support more informed, data-driven decision-making. Their growing application also has considerable potential to increase resilience and sustainability in the face of evolving economic, environmental, and social challenges.

Recognising the strategic importance of digital transformation, the Economic Research Institute for ASEAN and East Asia (ERIA) has actively supported the adoption of digital technologies across the region, particularly in sectors that are critical to inclusive and sustainable development. Agriculture and food systems are amongst these priority sectors. They provide livelihoods for millions of people across ASEAN, underpin regional food security, and make an important contribution to economic growth. At the same time, they face mounting pressures arising from climate change, resource constraints, labour shortages, changing consumer demands, and increasingly complex supply chains.

Against this backdrop, ERIA launched the research project *Benefits and Challenges of Digitalisation in Agriculture and Food Systems for Enhanced Resilience and Improved Sustainability*. At the 45th Meeting of the ASEAN Ministers on Agriculture and Forestry (AMAF) in 2023, I introduced this initiative and outlined ERIA's ongoing work to promote digital transformation in ASEAN's agriculture and food systems. The Ministers welcomed the initiative and expressed their expectation that ERIA would continue contributing to the advancement of digital agriculture in the region. The preliminary assessment presented in this report forms an important component of that broader research agenda. It also complements regional initiatives, including the *ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for the ASEAN Food and Agriculture Sector*, which provided an important reference for this study.

Drawing on evidence from eight ASEAN Member States, this report assesses the current adoption of digital technologies across agricultural production and food value chains, identifies key barriers to wider utilisation, and highlights emerging opportunities to accelerate digital transformation. It further examines how digital technologies can contribute to higher agricultural productivity, more efficient resource use, greater resilience, and improved sustainability, while providing practical policy recommendations for both national governments and ASEAN as a whole.

I would like to express my sincere appreciation to the research team, contributors, and experts from the ASEAN Member States who generously shared their knowledge and experience throughout this study. Their valuable contributions have strengthened the quality and relevance of this report.

I hope this publication will serve as a useful resource for policymakers, researchers, development partners, and practitioners seeking to advance the digital transformation of agriculture and food systems across ASEAN. Through continued regional co-operation, knowledge sharing, innovation, and public–private collaboration, ASEAN is well positioned to harness the full potential of digital technologies to build more productive, resilient, sustainable, and inclusive agriculture and food systems for future generations.

Tetsuya Watanabe

President
Economic Research Institute for ASEAN and East Asia (ERIA)

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List of Abbreviations and Acronyms

ADA	Agriculture Development Area
AI	Artificial Intelligence
AITI	Authority for Info-communications Technology Industry
AMAF	ASEAN Ministers on Agriculture and Forestry
AMI	Viet Nam Agricultural Market and Institution Research Institute
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
AWR	Agriculture War Room
DEPA	Digital Economy Promotion Agency
DoAA	Department of Agriculture and Agribusiness
ERIA	Economic Research Institute for ASEAN and East Asia
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographic Information Systems
ICT	Information and Communication Technology
IoT	Internet of Things
MOAC	Ministry of Agriculture and Cooperatives
NAP	National Agrifood Policy
NGO	Non-governmental Organisation
QR	Quick Response (Code)
QRIS	Quick Response Code Indonesian Standard
RA	Republic Act
RS	Remote Sensing
SRY	Special Region of Yogyakarta

Overview

Agriculture and food systems (agri-food systems) in the Association of Southeast Asian Nations (ASEAN) region play a pivotal role in ensuring food security and economic stability. However, these systems are increasingly exposed to multiple interconnected challenges, including climate change, resource constraints, labour shortages, and market volatility. Addressing these challenges whilst meeting rising food demand requires improvements in productivity, resilience, and sustainability across agricultural value chains. In this context, digital technologies have emerged as an important enabler for transforming agriculture and food systems by supporting more efficient production, improved market access, and better risk management.

Recognising the growing importance of digitalisation, ASEAN Member States (AMS) have increasingly incorporated digital technologies into agricultural development strategies. This direction has been reinforced at the regional level through initiatives such as the *ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises*, adopted at the 43rd ASEAN Summit in September 2023. The Declaration highlights the importance of accelerating digital transformation and the adoption of innovative technologies through co-operation and technology sharing amongst AMS. These efforts aim to strengthen agri-food systems, improve farmers' incomes, support capacity building, address climate challenges, reduce emissions and food loss, ensure food safety, and meet consumer needs. In line with this regional commitment, the Economic Research Institute for ASEAN and East Asia (ERIA) has undertaken this regional assessment to better understand the current status, challenges, and future prospects of digital agriculture in ASEAN.

This report aims to provide an evidence-based overview of how digital technologies are currently utilised across agricultural production and food value chains in ASEAN, the key barriers hampering their wider adoption, and the extent to which existing policy frameworks support digital transformation. The study presents empirical data collected through surveys and interviews with a broad range of stakeholders, including farmers, co-operatives, agribusinesses, technology providers, and other actors along the agriculture value chain. The assessment covers eight ASEAN countries and focuses on major agricultural commodities such as rice, fruits and vegetables, livestock and poultry, and aquaculture.

The analysis examines the use of digital technologies across three main areas: (i) agricultural production, including advisory services, drones, Internet of Things (IoT) sensors, automation, and data management tools; (ii) distribution, marketing, and financing, such as digital marketplaces, mobile applications, and digital payment systems; and (iii) digital traceability systems. In addition, the report explores stakeholders' perceptions of priority areas for digital solutions, identifies key constraints related to infrastructure, human capacity, finance, and institutional co-ordination, and reviews government and private sector support for digital agriculture.

This report comprises 11 chapters, starting with an introduction and regional analysis, followed by Chapters 3–10, which present country-level findings, highlighting differences in adoption levels, priority needs, policy awareness, and institutional contexts across AMS. The chapters show that whilst digital agriculture is progressing in the region, adoption remains uneven across countries and stages of the value chain. Digital tools are most widely applied at the production stage and in market-related activities, whereas adoption in post-harvest management, traceability, and integrated data systems remains low. The country analyses also reveal various constraints, such as limited infrastructure for mechanisation and connectivity, low digital literacy, high technology costs, and fragmented policy frameworks. These continue to hinder the wider diffusion of digital technologies.

Building on the country findings, the concluding chapter emphasises regional patterns and assesses future expectations for digital agriculture in ASEAN. This study finds that farmers and other stakeholders have high expectations for market-oriented digital solutions, particularly digital marketplaces and e-commerce platforms, followed by emerging technologies such as drones, IoT-based sensors, and artificial intelligence. At the same time, the assessment confirms that effective digitalisation cannot rely on technology provision alone. Enabling environments that integrate effective policies, targeted investments, capacity building, and co-ordinated public–private engagement are critical to ensure that digital agriculture contributes to inclusive, resilient, and sustainable agricultural development in ASEAN.

Chapter 1
Introduction

Masanori Kozono

1.1 Overview of Digitalisation in Agriculture and Food Systems in ASEAN

The Association of Southeast Asian Nations (ASEAN) is now a major player in the global economy and the fourth-largest economy in the world (International Monetary Fund, 2025). In such a growing economy, agriculture and its related sectors maintain a strategic position in ASEAN, serving as a vital source of employment and contributing to a significant portion of income for the region's population. More importantly, they contribute significantly to ensuring both national and regional food security and nutrition in ASEAN through their role as a stable supply source of food commodities.

Agriculture and food systems (agri-food systems) are facing multiple challenges, such as increasing food demand for growing populations, rising malnutrition, the adverse impacts of climate change such as floods, drought, outbreaks of pest and plant diseases, overexploitation of natural resources, ever-increasing carbon emissions, loss of biodiversity, ageing farming populations, and food loss and waste. Furthermore, recent sudden external shocks, such as the COVID-19 pandemic and the escalation of geopolitical tensions, have directly and indirectly impacted agri-food systems through supply chain disruptions in terms of food commodities and agricultural inputs like fertilisers.

In recent years, the utilisation of digital technologies has emerged as a critical tool and key measure in overcoming these challenges and promoting the sustainability and resilience of agri-food systems. Digital technologies offer innovative solutions for enhancing productivity, optimising resource allocation, improving market access, ensuring traceability along the supply chain, and promoting sustainable practices in agri-food systems. Several countries in the region are witnessing various initiatives for leveraging digitalisation in agri-food systems. Examples in production include precision agriculture utilising a combination of data and digital equipment to manage farming with a high level of accuracy, drones for assessing crop growth precisely and for spraying farming inputs selectively, such as fertiliser, pesticides, herbicides and insecticides, and GPS systems that contribute to the practice of sustainable agriculture through optimising resource use, improving crop yields, and reducing environmental impact. In addition, farming advisory services based on digital information can lead to maximising yields, with better production practices observed in some ASEAN countries. Along the food supply chain, digital agriculture trading through the digital marketplace has been rapidly emerging across the region since the COVID-19 pandemic. Digital agriculture trading can streamline marketing and distribution processes, reduce intermediaries, and ensure fair market access for farmers through digital tools and platforms. QR code traceability systems, primarily operated by specific private companies, have also been used in some ASEAN countries. These traceability systems provide information on product origin and farmer identity, providing buyers and consumers with greater confidence in food safety and quality.

Generally, the use of these digital technologies in agriculture production and along supply chains promotes the transition from conventional agriculture and supply chains to a more resilient and sustainable form. However, it should be noted that these success cases are limited to some countries in the region. A study conducted by ERIA in 2024 implied that the diffusion of digital agriculture in the ASEAN region is limited, and there is a noticeable gap amongst ASEAN countries (Kozono et al., 2025).

1.2 ASEAN Collective Initiatives for Promoting Digitalisation in Agriculture and Food Systems

Digital technologies can offer innovative solutions for addressing the challenges faced by ASEAN countries in agri-food systems through increasing productivity, improving market access, optimising resource allocation, and ensuring traceability. Recognising this potential, the governments of ASEAN countries have been making efforts to establish policy and regulatory frameworks and implement various programmes for promoting digitalisation in agriculture, although digitalisation has been progressing in different ways from country to country and remains uneven.

For example, Indonesia's food self-sufficiency programme includes an agricultural digitalisation programme to drive digital transformation across the agriculture sector by strengthening data-driven planning, enhancing digital literacy, and implementing real-time monitoring (Ministry of State Secretariat of Indonesia, 2025). THAGRI, a digital platform in Thailand, connects farmers to share data and information on the agriculture sector (THAGRI, n.d.). It also works as a data collaboration platform amongst farmers and consumers. Whilst some ASEAN countries are making progress in government-led efforts to digitalise the agriculture sector, there are also countries where intensive efforts for digitalisation have yet to be made in the agriculture sector.

At the regional level, ASEAN has taken collective initiatives to produce several regional strategic papers for accelerating digitalisation in agri-food systems since around 2020.

In the 'Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry (2016-2025)', which was endorsed at the 37th ASEAN Ministers on Agriculture and Forestry (AMAF) meeting in 2015, the word 'digital' does not appear at all (ASEAN Secretariat, 2015). Amongst related terms, only the 'use of information and communications technology (ICT)' is mentioned as a new extension method for disseminating successful technologies. This suggests that digitalisation in agriculture was not yet clearly envisaged in the context of ASEAN's agricultural development at the time. Furthermore, the 'ASEAN Integrated Food Security (AIFS) Framework and Strategic Plan of Action on Food Security in the ASEAN Region (SPA-FS) 2021-2025', which was adopted at the 42nd AMAF meeting in 2020, did not contain any statement on the use of digital technology. The AIFS Framework is a regional umbrella for initiatives related to food security.

The major turning point when the use of digital technology in agriculture began to attract attention in ASEAN strategic papers was the 'ASEAN Comprehensive Recovery Framework (ACRF)', which was adopted at the 37th ASEAN Summit in 2020, and its Implementation Plan (ASEAN Secretariat, 2020). The ACRF is the key regional strategy for the region's recovery from the COVID-19 pandemic. One of the five broad strategies for recovery is 'Accelerating Inclusive Digital Transformation', which includes promotion of micro, small, and medium-sized enterprise digital upskilling and the adoption of digital technologies by ASEAN businesses. In the Implementation Plan of the ACRF, the development of the 'ASEAN Guidelines on the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector' in 2021 was specifically raised. In response to this plan, several regional workshops were held for ASEAN Member States, with the participation of resource persons from the private sector, academia, and international organisations, to discuss the actual status of digitalisation in ASEAN agriculture, potential technologies, government initiatives, and the contents of the guidelines. Based on the evidence-based information and regional consultations supported by ERIA through the organisation of an expert team and workshops, the draft guidelines were prepared. The 'ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector', which is the first strategic paper focusing on digital agriculture in ASEAN, was adopted at the 43rd AMAF meeting in October 2021 (ASEAN Secretariat, 2021). It is comprehensive and covers various aspects, such as the use of technologies, the enabling environment, and capacity building, aiming to provide guidance not only for ASEAN governments but also for various stakeholders in agri-food systems.

In 2023, the 'ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises' was adopted at the 43rd ASEAN Summit in September (ASEAN Secretariat, 2023). This declaration is the first political commitment by the heads of state and government of ASEAN countries to strengthen food and nutrition security. It consists of 18 concrete initiatives to strengthen food security and nutrition. Amongst them, accelerating digital transformation is highlighted as a way to increase productivity and resilience in agri-food production, improve farmers' income, address the challenges of climate change, reduce greenhouse gas emission, meet consumer needs, and so forth.

In 2024, the 'Action Plan on Sustainable Agriculture in ASEAN' was endorsed at the 46th AMAF meeting in October (ASEAN Secretariat, 2024). It is expected to serve as a roadmap for enhancing co-operation and knowledge sharing on sustainable agricultural transformation in the ASEAN region. As one of five key strategic priorities in this action plan, digitalisation in agriculture is highlighted, with reference to digital technologies such as precision agriculture, artificial intelligence (AI), remote sensing, Internet of Things (IoT), and data analytics in achieving enhanced productivity and efficiency in agriculture and resilient agricultural value chains.

Most recently, digitalisation in agri-food systems was highlighted in the 'Food, Agriculture and Forestry Sectoral Plan (FAF-SP) 2026-2030', which was adopted at the 47th AMAF meeting in October 2025 (ASEAN Secretariat, 2025). In the sectoral plan, agricultural digitalisation is addressed under Strategic Thrust (ST) 5: Fostering Public-Private Partnerships, Agricultural Cooperatives and Digital Innovation in FAF Sectors. However, the utilisation of digital technologies is also mentioned repeatedly across the other STs, including ST1: Promoting Sustainable and Regenerative Measures; ST3: Strengthening Food Security and Nutrition; and ST4: Promoting Trade and Market Connectivity. This implies that digital solutions are now becoming indispensable for addressing various challenges in agri-food systems. The relevant ASEAN strategic papers are listed in Table 1.1.

Table 1.1. ASEAN Strategic Papers Related to Digitalisation in Agri-food Systems

Year	ASEAN strategic papers	Adopted/ endorsed at
2020	**ASEAN Comprehensive Recovery Framework (ACRF) and its Implementation Plan** - The Implementation Plan includes an initiative to develop the ASEAN Guidelines on the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector.	ASEAN Summit

2021	**ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector** - The first regional strategic paper focusing on the use of digital technologies in the agricultural sector. - The guidelines emphasise not only the type of technologies but also accessibility, inclusiveness, and good governance to accelerate digitalisation in agriculture.	AMAF meeting
2022	**ASEAN Regional Guidelines for Sustainable Agriculture in ASEAN** - Smart and precision agriculture using sensors and monitoring systems is highlighted as one of 28 key strategies.	AMAF meeting
2023	**ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises** - As one of the ASEAN Leaders' commitments, accelerating digital transformation in agri-food systems is highlighted.	ASEAN Summit
2024	**Action Plan on Sustainable Agriculture in ASEAN** - One of the five key strategic priorities is digitalisation in agriculture.	AMAF meeting
2025	**Food, Agriculture and Forestry Sectoral Plan (FAF-SP) 2026-2030** - One of six Strategic Thrusts focuses on fostering digital innovation. In addition, the utilisation of digital technologies is referred to many times in the other Strategic Thrusts.	AMAF meeting

Source: Authors' compilation.

To support ASEAN's efforts to accelerate digitalisation in its agri-food systems, ERIA launched a comprehensive project in 2024, titled 'Benefits and Challenges of Digitalisation in Agriculture and Food Systems for Enhanced Resilience and Improved Sustainability', which includes conducting research and organising regional workshops and symposiums focusing on digital agriculture. As part of the project, ERIA carried out a preliminary assessment study in 2025. This study report summarises the outline and results of the preliminary study.

1.3 Framework of ERIA's Preliminary Assessment Study

1.3.1 Background and Objectives

As mentioned, ASEAN has been conducting regional collective initiatives, such as producing policy and strategic papers, to accelerate digitalisation in agri-food systems in the region. To support these regional efforts, ERIA conducted this regional study to assess the landscape of digitalisation in ASEAN's agri-food systems.

This study primarily aims to provide evidence-based policy recommendations to promote digitalisation in agri-food systems in ASEAN. It assesses the current utilisation of digital tools across agricultural value chains, barriers to technology diffusion, enabling policy frameworks, and the future prospects of digital agriculture in ASEAN, based on analysis of data and information collected through field surveys, including interviews.

1.3.2 Study Method and Report Structure

To conduct this study, ERIA collaborated with experts on digital agriculture from nine universities in eight ASEAN countries: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, the Philippines, Thailand, and Viet Nam. To collect data, interviews and discussions with respondents were carried out from January to May 2025, using a pre-set questionnaire developed by ERIA in consultation with experts. There were 824 respondents in total from the eight countries mentioned above, with approximately 100 respondents per country. The respondents were mainly farmers and other agricultural value chain actors who had already utilised digital technologies in their operations. A purposive sampling method was applied to select respondents. The questionnaire covered topics such as digital technologies already utilised, areas requiring digital solutions, challenges in introducing digital technologies, government initiatives, support from the government and private sector, and future prospects for the application of digital technologies in agri-food systems.

Chapter 2 outlines the study method, including the contents of the questionnaire, and discusses the ASEAN regional overview. Chapters 3–10 focus on country-specific analysis of each ASEAN country. This project report concludes with Chapter 11, which presents the conclusion and recommendations drawn from the results of the previous chapters.

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Chapter 2
Digitalisation in Agriculture and Food Systems for Enhanced Resilience in ASEAN

Mohana Sundaram Shanmugam and Jayanga Kodikara

2.1 Background

Agriculture and food systems are facing growing food demand both locally and globally, driven by population growth and changing consumption patterns. At the same time, they are increasingly challenged by factors such as climate change, resource scarcity, and market fluctuations. These challenges need to be addressed urgently to avoid stress accumulation and mitigate declining resilience in agriculture and food systems, which are critical to the economies of many regions. Moreover, their environmental footprint is significant, mainly due to resource overuse, excessive use of pesticides and fertilisers, and greenhouse gas emissions. Addressing these challenges whilst meeting growing demand requires the identification and adoption of innovative approaches that support sustainable and resilient solutions in agriculture and food systems.

Digitalisation is transforming the world and has made significant progress in recent years in the field of agriculture and food systems. These initiatives have the potential to address challenges in agriculture and food systems globally. They include the deployment of drones, the Internet of Things (IoT), precision agriculture techniques, and e-commerce technology. Such initiatives have been identified as the 'key to developing sustainable agriculture' (Walter et al., 2017). The increasing use of information and communication technology in agriculture has been regarded as the Fourth Agricultural Revolution (Walter et al., 2017).

Digitalisation in agriculture and food systems has recently been implemented across ASEAN Member States to enhance productivity, improve resilience, address the adverse impacts of climate change, and manage rising market uncertainties. As digital transformation progresses, the aim is to achieve sustainability in agriculture and food systems by leveraging potential opportunities and mitigating potential risks and barriers. Digital technologies have been introduced to increase productivity, enhance resilience, and reduce the environmental footprint of agriculture and food systems. However, the success of digital agriculture and food systems has been limited to certain countries in the region (Kozono et al., 2024). A previous study conducted by ERIA in 2023 clearly highlighted the gaps amongst countries in the adoption and spread of digital agriculture across the ASEAN region

(Kozono et al., 2023).

In the 'ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises' adopted at the ASEAN Summit in September 2023, the importance of digitalisation in agriculture and food systems was strongly emphasised, paving the way for accelerating digital transformation in the region. This initiative aims to address the impacts of climate change on agriculture, reduce greenhouse gas emissions, and minimise food loss and waste. In alignment with this direction, ERIA has committed to promoting the utilisation of digital technologies to support sustainable agriculture and food systems across ASEAN countries.

In light of these regional commitments, this preliminary study was conducted to understand both the challenges and benefits associated with digitalisation in agriculture and food systems. This study examines the barriers to the widespread use of digital technologies, such as infrastructure limitations, connectivity with rural areas, digital literacy, data security, limited government support, and funding constraints. The long-term implications for development in agriculture and food systems were also discussed in this study. The analysis examines existing digital policy instruments to inform and strengthen agricultural policies focused on resilience and sustainability, particularly in the context of smallholder farmers.

2.2 Research Method

2.2.1 Questionnaire Development

The questionnaire was developed based on expert insights and a literature review on digitalisation in agriculture and food systems for enhanced resilience and sustainability. It was then translated into the local languages to aid in comprehension at the national level.

It aims to evaluate current methodologies for adopting digital technologies and to capture respondents' perspectives on strengthening resilience and sustainability in the sector.

The questionnaire format was designed to ensure clarity for the target audience (respondents). Local language versions were prepared to facilitate understanding at the country level. In addition to the choices provided for each question, a common column was included for respondents to comment on other initiatives they were aware of, ensuring that the actual situation was accurately recorded. The finalised questionnaire structure is shown in Table 2.1. The questionnaire is also attached as an appendix.

Table 2.1. Structure of the Questionnaire

No.	Question code	Question	Response format
1	Meta data	Respondent identity details	Record respondent category, commodity type, years of experience, farm size, gender, and other relevant meta data
2	A.Q1	Status of utilising digital technologies and tools in agriculture production and along the food value chain	Select all digital technologies and tools currently used in farming activities
3	A.Q2	Areas in the agriculture and food value chain that require digital solutions	Select all applicable options from the given choices and specify any others, if applicable
4	A.Q3	Existing challenges, constraints, and obstacles in using digital technologies and introducing digital solutions	Select all applicable options for the given choices and specify any others, if applicable
5	B.Q4	Government initiatives supporting the use of digital technologies and tools in agriculture and along the food value chain	Answer 'Yes' or 'No'. If 'Yes', specify whether support is sufficient or insufficient
6	B.Q5	Awareness of country-level policies promoting the use of digital technologies and solutions	List up to three existing policies in the respondent's country and indicate their level of awareness of each
7	B.Q7	Supportiveness of each policy to agricultural and food value chain activities	Select the most appropriate option from a 5-point Likert scale ranging from 'Agree' to 'Disagree'
8	C.Q7	Private sector support for the use of digital technologies and tools in agriculture and along the food value chain	Answer 'Yes', 'No', or 'Unsure'. If 'Yes', specify the type of the private sector entity
9	C.Q8	Type of support received from the private sector for the use of digital technologies and tools in agriculture and along the food value chain	Select all applicable options for the given choices and specify any others, if applicable
10	D.Q9	Digital technologies that can impact the future of agriculture	Select all applicable options for the given choices and specify any others, if applicable

Source: Authors' compilation.

2.2.2 Respondents and Interviews

Respondents were purposively selected to ensure representation across all key stakeholders in the agriculture and food value chain. These included individuals engaged in farming, wholesaling, processing, distribution, co-operative management, technology provision, and end consumption. The selection criteria were designed to capture diverse perspectives and experiences within the sector.

The study focused on the most prominent agricultural commodities in the region, namely rice, fruits and/or vegetables, livestock, poultry, and aquaculture. These commodities were chosen due to their significant contribution to regional agriculture production and trade.

Data were collected using a combination of methods to enhance reliability and depth of information. These methods included face-to-face interviews, facilitated group discussions, and online survey forms. This mixed-method approach enabled the inclusion of respondents from various geographical locations and ensured comprehensive coverage of the research objectives. The demographic and professional profiles of the respondents are presented in Table 2.2.

Across the selected ASEAN countries, the majority of respondents were farmers, with a share often exceeding 70%. Other categories such as wholesalers, processors, distributors, and co-operatives were comparatively underrepresented. However, Lao PDR included more co-operative members (6%) and consumers (12%) than other countries. The gender distribution shows a male majority in most ASEAN countries. However, Lao PDR had the highest proportion of female respondents of 67%. In addition to the main categories, respondents, also included company representatives, researchers, seed growers, farm administrators, livestock farmers, management staff, and quality assurance/control officers.

Table 2.2. Extracted Metadata on Respondent Categories

ASEAN country	Number of respondents	Gender (%)		Category of the respondents (%)							
		Male	Female	Farmer	Wholesaler	Processor	Distributor	Co-operative	Technology provider	Consumer	Other
Brunei Darussalam	82	87	13	95	0	1	0	0	4	0	0
Cambodia	119	65	35	86	1	0	3	0	9	0	1
Indonesia	100	69	31	87	1	3	5	0	3	0	1
Lao PDR	100	33	67	74	0	2	0	6	4	12	2
Malaysia	100	83	17	75	2	1	2	3	8	3	6
Philippines	100	66	34	70	2	4	1	4	12	6	0
Thailand	120	66	34	93	3	2	3	0	0	0	0
Viet Nam	103	62	38	82	5	3	1	5	1	2	2

Source: Authors' compilation.

The agricultural commodities cover a wide range of production systems, including rice, fruits and vegetables, livestock and poultry, aquaculture, and other crops cultivated at varying levels of importance across selected ASEAN countries (Table 2.3).

Table 2.3. Extracted Metadata on Agricultural Commodities

ASEAN country	Agriculture commodity (%)					
	Rice	Fruits and/or vegetables		Livestock and poultry	Aquaculture	Others
		Traditional	Greenhouse			
Brunei Darussalam	12	26	23	6	23	10
Cambodia	59	16	21	3	0	2
Indonesia	36	35	8	2	1	18
Lao PDR	28	63	0	0	9	0
Malaysia	15	8	54	5	14	4
Philippines	46	22	3	16	2	10
Thailand	21	48	15	7	3	8
Viet Nam	94	2	0	1	0	3

Source: Authors' compilation.

The respondents had different levels of farming experience, ranging from less than 5 years to more than 20 years, and possessed diverse educational backgrounds spanning primary, secondary, vocational, and higher education (Table 2.4).

Table 2.4. Extracted Metadata on Respondents' Experience and Education

ASEAN country	Years of experience (%)				Education			
	< 5 years	5–10 years	11–20 years	> 20 years	Primary	Secondary	Vocational	Higher
Brunei Darussalam	30	44	16	10	2	17	5	76
Cambodia	34	24	14	28	41	37	1	21
Indonesia	18	41	19	22	10	41	8	41
Lao PDR	20	39	35	6	42	38	6	14
Malaysia	28	50	15	7	0	33	3	64
Philippines	19	28	17	36	1	11	7	81
Thailand	17	50	21	13	1	17	18	64
Viet Nam	12	14	28	47	14	67	5	15

Source: Authors' compilation.

2.2.3 Compilation of Results for Analysis

The survey data were entered into an Excel spreadsheet and subsequently prepared for analysis. Before conducting the analysis, the dataset was carefully reviewed to ensure completeness and to identify and correct any inconsistencies.

A systematic data cleaning process was applied to validate the ratio of responses and to preserve the integrity of the comments and opinions provided by the respondents. The analysis procedure was designed according to the type of question, as depicted in Table 2.5.

Table 2.5. Summary of Survey Questions, Response Types, and Analysis Procedures

Question code	Expected response type	Expected analysis procedure
A.Q1, A.Q2, A.Q3, and D.Q9	Multiple-choice (multiple responses allowed)	Compile results and present as ratios of total respondents
B.Q4	Yes/No (single response)	Count responses and present as ratios of total respondents
B.Q5	Policy identification and awareness level	Present results as ratios and summarise key initiatives
B.Q6	Likert-scale (single response)	Summarise as frequencies and ratios
C.Q7	Yes/No/Unsure (single response)	Summarise as frequencies and ratios
C.Q8	Multiple-choice (multiple responses, only if 'Yes' in C.Q7)	Compile results and present as ratios of total respondents

Source: Authors.

Qualitative responses, such as comments, were categorised and summarised to highlight key themes. All the results are presented as ratios of the total respondents and summarised by country.

2.2.4 Scope and Limitations

Extensive scope: The report categorises technologies into production, distribution/marketing/finance, and digital traceability, encompassing a broad range of digital agriculture applications. Additionally, it methodically tackles several challenges, including institutional factors, financial considerations, human resources, basic infrastructure, and digital data management. This comprehensive method provides a holistic view of digitalisation in agriculture.

Multi-stakeholder perspective: All major players in the agriculture and food value chain, including farmers, wholesalers, processors, distributors, co-operative managers, technology suppliers, and consumers, were purposefully chosen as respondents. This guarantees that a range of viewpoints is recorded. To increase reliability and cover a range of geographic locations, a mixed-method approach was used for data collection, including in-person interviews, group discussions, and online surveys.

Nature: The report clearly states that it is preliminary in nature and will be used to assess more in-depth country case studies in the future. This suggests that, although the results are insightful, they are general and may not be as detailed as those required for highly localised interventions.

Sampling bias and underrepresentation: In the study, farmers made up the majority of respondents (often over 70% in ASEAN nations), whilst wholesalers, processors, and distributors were relatively underrepresented. A 'production-centric bias' may result from this, in which the viewpoints of primary producers may take precedence over those of midstream and downstream value chain participants.

Variability across countries: For nearly every factor analysed, including technology use, priority needs, difficulties, and government support, the report regularly identifies 'significant variation across countries'. This high variability implies that a pan-ASEAN 'one-size-fits-all' approach is inappropriate, even though it provides an average for ASEAN. Additionally, generalised averages may obscure important country-specific nuances.

2.3 Results of the Study

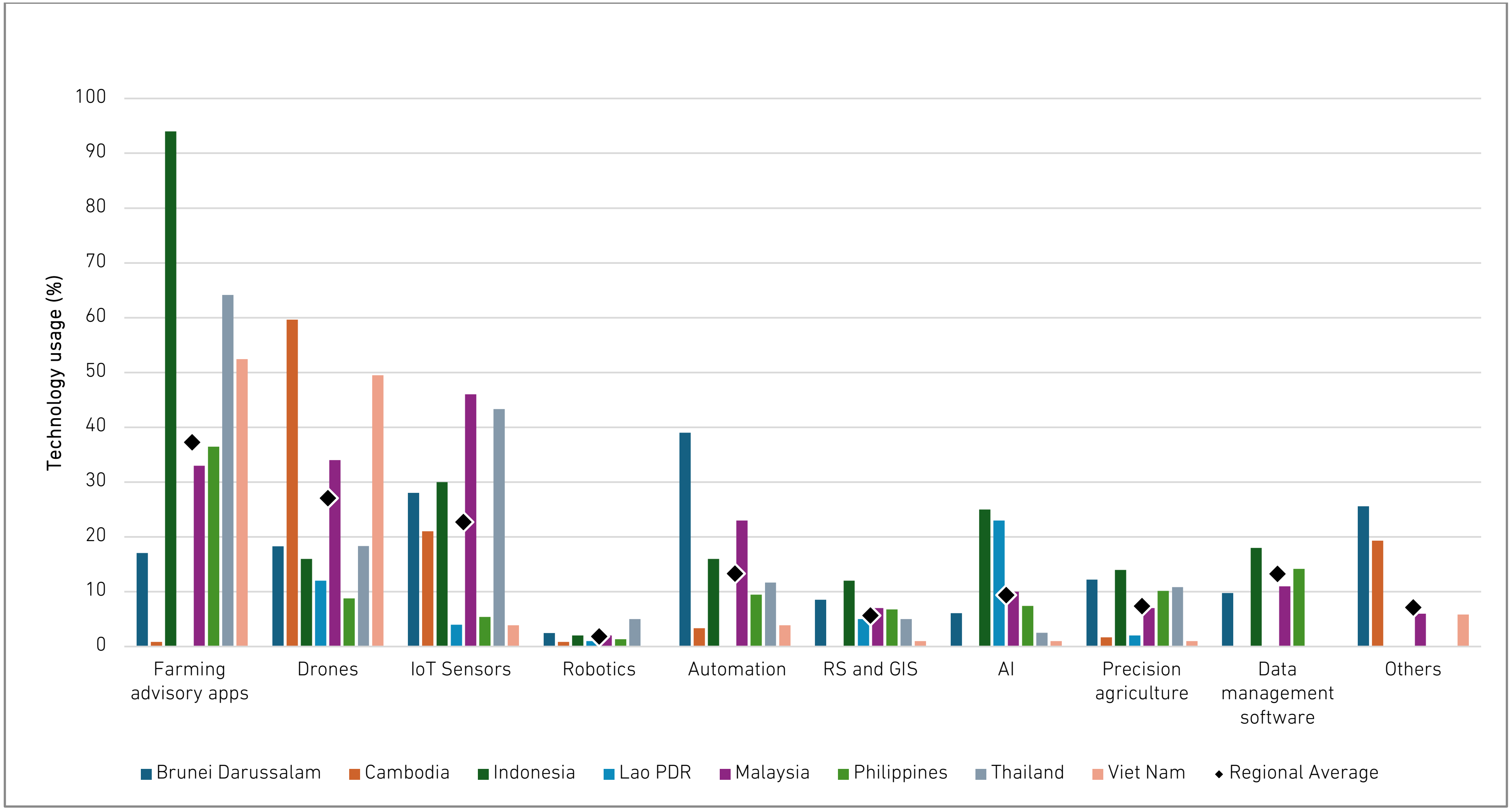
2.3.1 Current Status of Utilising Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain

The different types of digital technologies and tools already used in farming activities along the food value chain were grouped into three categories: production; distribution, marketing, and financing; and digital traceability of farm commodities in domestic and international markets.

2.3.1.1 Production

Figure 2.1 depicts the share of respondents in each selected ASEAN Member State who reported using different types of digital technologies and tools in agricultural production and along the food value chain. The technologies considered in the survey include farming advisory applications, drones, IoT sensors, robotics, automation, remote sensing (RS) and geographic information systems (GIS), artificial intelligence (AI), precision agriculture, data management software, and other tools.

Figure 2.1. Status of Utilising Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain Across Countries – Production



Source: Authors' compilation.

The results show significant variation across countries. For example, Indonesia reported the highest overall utilisation of 94% in production-related technologies, whilst Cambodia (1%) and Lao PDR (0%) recorded the lowest. Malaysia, the Philippines, Thailand, and Viet Nam showed average digital technology utilisation levels of 33%, 36%, 64%, and 52%, respectively. The utilisation of specific tools also varied widely across the selected ASEAN countries; farming advisory apps were most used in Indonesia (94%), drones in Cambodia (60%), IoT sensors in Malaysia (33%), robotics in Thailand (5%), automation technologies in Brunei Darussalam (39%), and RS and GIS, AI, precision agriculture, and data management software in Indonesia (12%, 25%, 14%, and 18%, respectively).

In the analysis of digital technology production across the selected eight ASEAN countries, Indonesia leads with the highest production, followed by Malaysia, Thailand, and Brunei Darussalam. Meanwhile, Viet Nam, Cambodia, the Philippines, and Lao PDR show relatively lower production levels.

On average, across the selected eight countries, 14% of respondents reported using production-related technologies, with 37% using farming advisory apps, 27% using drones, 23% using IoT sensors, 2% using robotics, 13% using automation, 6% using RS and GIS, 9% using AI, 7% using precision agriculture, 13% using data management software, and 7% using other tools. It was observed that the advanced tools, such as robotics, automation, and AI, show lower adoption. In Malaysia, REDTone smart farming technologies are applied alongside semi-automated fertigation techniques. In Brunei Darussalam, production practices incorporate solar panels, drip irrigation, hydroponic systems, and weather applications in addition to the digital tools mentioned earlier. Other popular tools in production in Cambodia include applications linked with solar companies, as well as QR and barcode technologies.

2.3.1.2 Distribution, Marketing, and Financing

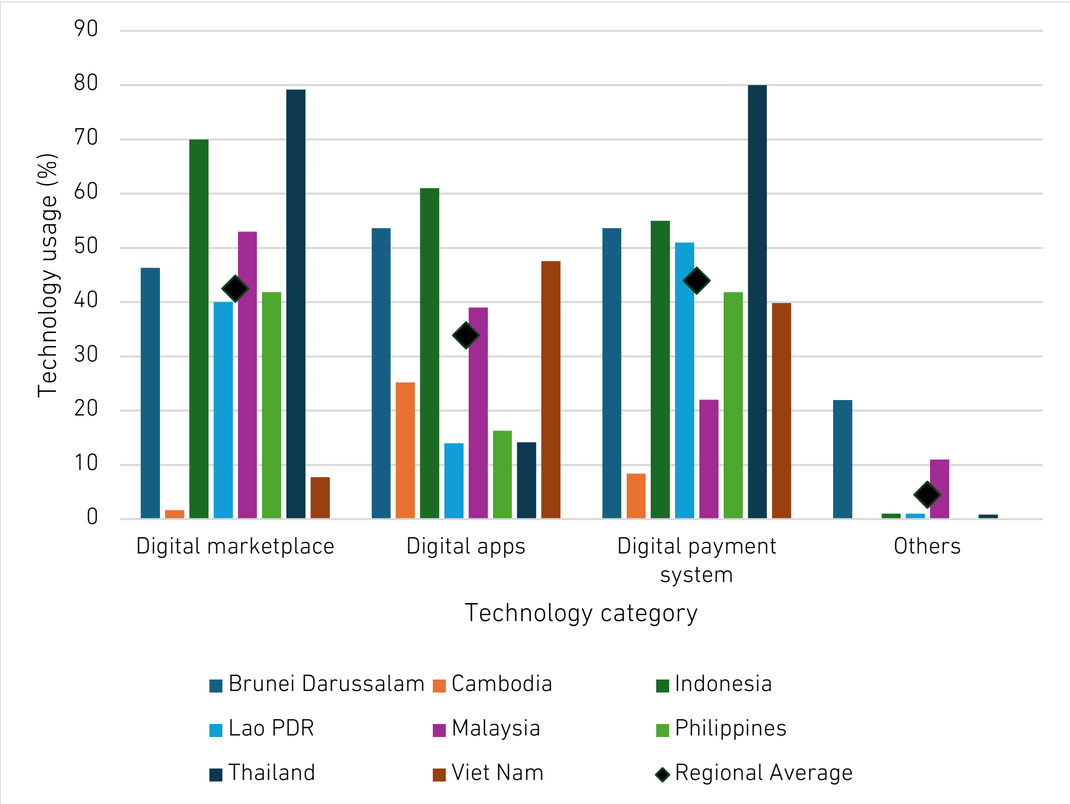
The shares of respondents in the selected ASEAN countries who reported using digital technologies and tools for distribution, marketing, and financing activities within the agriculture and food value chain are shown in Figure 2.2. The technologies considered include the digital marketplace, digital apps for distribution, digital payment systems, and other digital tools.

Thailand, Indonesia, and Brunei Darussalam demonstrated relatively high engagement with these digital solutions, with average utilisation ranging from 44% to 47%, whereas Cambodia showed much lower engagement of 9%. Other countries, namely Malaysia, Lao PDR, the Philippines, and Viet Nam engage in the mid-range from 24% to 31%.

Breaking down the adoption by specific technologies, the digital marketplace was most widely used in Thailand (79%) and Indonesia (70%), whilst Cambodia (2%) and Viet Nam (8%) reported minimal use. Digital applications were popular in Indonesia (61%) and Brunei Darussalam (54%), but usage of digital applications was lower in Thailand (14%), Lao PDR (14%), and the Philippines (16%). Digital payment systems were strongly adopted in Thailand (80%), with mid-range engagement in Brunei Darussalam (54%), Indonesia (55%), and Lao PDR (51%). The use of other tools in distribution, marketing, and financing remained limited across all countries, averaging only 4%.

Across the eight countries, an average of 31% of respondents reported using digital technologies in distribution, marketing, and financing. Digital marketplaces (42%) and payment platforms (44%) emerged as the most commonly employed tools, followed by digital applications (34%), whilst other tools were scarcely used. These results suggest that these ASEAN countries are focusing on technologies that enhance distribution, marketing, and financing, but they are yet to gain significant traction.

Figure 2.2. Status of Utilising Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain Across Countries – Distribution, Marketing, and Financing



Source: Authors' compilation.

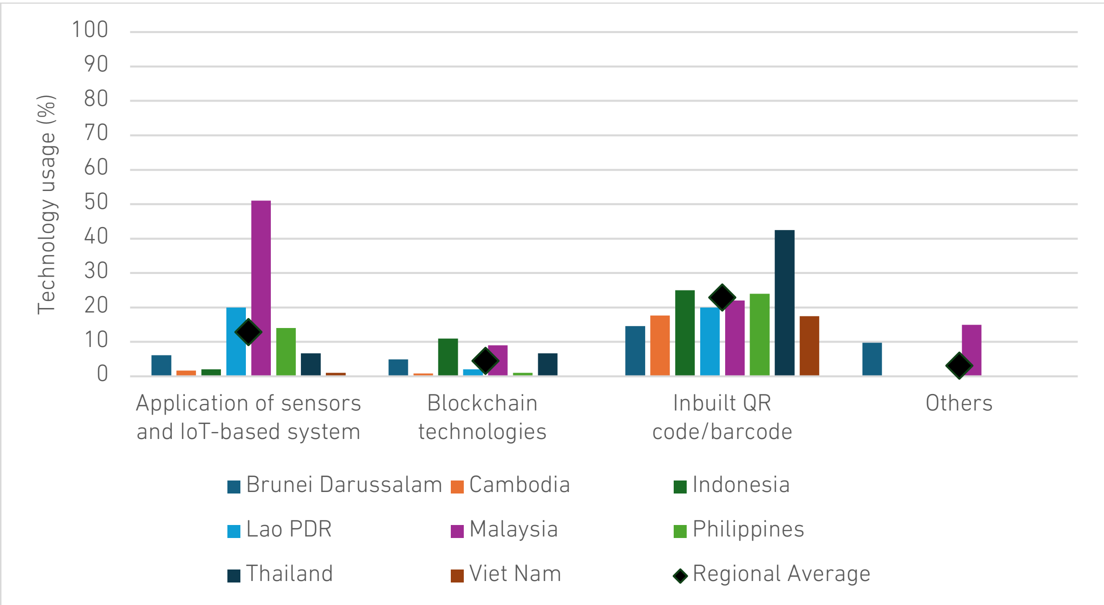
Social media platforms were particularly popular in Brunei Darussalam and Malaysia for distribution activities. In addition, respondents mentioned the use of money remittance systems, IoT central panels, AI-based weight scales, and AI technologies for determining fruit sizes.

2.3.1.3 Digital Traceability of Farm Commodities Within Domestic and International Markets

The shares of respondents from the selected ASEAN countries who reported using digital tools to enhance traceability of agricultural products in both domestic and international markets are shown in Figure 2.3. The survey considered technologies such as sensors and IoT-based systems, blockchain, inbuilt QR codes or barcodes, and other digital mechanisms.

In terms of specific tools, inbuilt QR codes or bar codes were identified as the most widely adopted technology, with Thailand reporting the highest use at 43%. Sensors and IoT-based systems were more frequently applied in Malaysia (51%), whilst blockchain technologies were limited across all eight countries, averaging only 4%. Other traceability tools were minimally adopted, with the highest use recorded in Malaysia (15%) and Brunei Darussalam (10%). Other traceability tools identified in the survey include social media platforms, electric fencing, IoT-based watering systems, seeding processors, camera detection technologies, feed cutters, and automated fertiliser applications.

Figure 2.3. Status of Utilising Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain Across Countries – Digital Traceability of Farm Commodities Within Domestic and International Markets



Source: Authors' compilation.

The results indicate considerable variation amongst the selected eight countries. Malaysia (24%) exhibited the highest average use of traceability technologies, whilst Cambodia (5%) and Viet Nam (5%) reported the lowest adoption. Moderate levels of traceability technology utilisation are seen in Brunei Darussalam (9%), Indonesia (10%), Lao PDR (11%), the Philippines (10%), and Thailand (14%).

Overall, across the eight ASEAN countries, an average of 11% of respondents reported using digital traceability solutions. The findings suggest that QR code and barcode systems dominate traceability tools, whereas emerging technologies like IoT and blockchain remain less prevalent.

2.3.2. Areas in the Agriculture and Food Value Chain That Require the Application of Digital Solutions

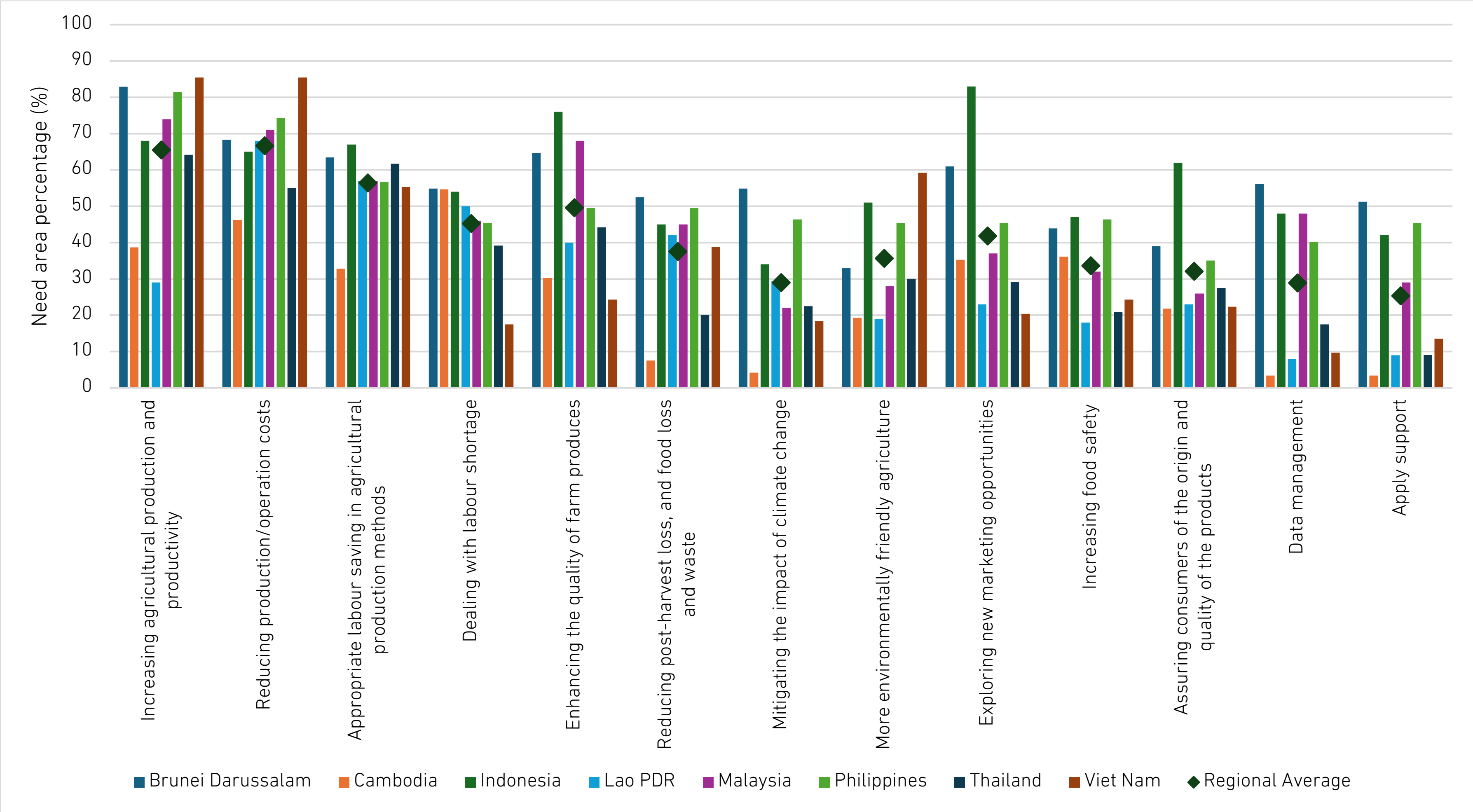
Percentages of priority needs identified by the respondents across the selected ASEAN countries in relation to the agriculture and food value chain are depicted in Figure 2.4. The results reveal distinct regional priorities. Brunei Darussalam, the Philippines, and Viet Nam showed the strongest demand to apply digital solutions to increase agricultural production and productivity (83%, 81%, and 85%, respectively), whereas Lao PDR was the lowest at 29%. Reducing costs was a key concern in Viet Nam (85%). Labour-saving in agricultural production methods was prioritised in Indonesia (67%), Brunei Darussalam (63%), and Thailand (62%). Demand for the application of digital solutions for dealing with labour shortages was highest in Brunei Darussalam (55%), Cambodia (55%), and Indonesia (54%) compared to the other selected countries.

The application of digital solutions to enhance the quality of farm products was especially emphasised in Indonesia (76%). According to the survey data for Brunei Darussalam, 65% of respondents required digital solutions to enhance the quality of farm products, whereas 52% required digital solutions to reduce post-harvest loss and food loss.

Climate change impact mitigation using digital solutions was considered most important in the Philippines (46%) and Brunei Darussalam (55%), whilst environmentally friendly agriculture using digital solutions was highlighted most in Indonesia (51%), the Philippines (45%), and Viet Nam (59%). In terms of applying digital solutions to explore new market opportunities, Indonesia demonstrated the strongest interest, with 83% of respondents highlighting this need. Digital solutions for increasing food safety and assuring consumers of the origin and quality of products were emphasised by Indonesia (47% and 62%, respectively), whereas Lao PDR, Thailand, and Viet Nam reported lower concern in these areas. Introducing digital solutions for data management, including data collection, analysis, storage, transfer, and sharing, was regarded as essential in Brunei Darussalam (56%), Indonesia (48%), Malaysia (48%), and the Philippines (40%). Respondents from Brunei Darussalam (51%), Indonesia (42%), and the Philippines (45%) emphasised that support mechanisms such as subsidies and insurance should be facilitated through digital solutions to ensure more effective service delivery.

On average, across the eight ASEAN countries, the top three priority areas that require digital solutions were reducing production/operation costs (67%), increasing agricultural production and productivity (65%), and introducing appropriate labour saving in agricultural production methods (56%). By contrast, relatively lower attention was given for introducing digital solutions for mitigating the impact of climate change (29%), data management (29%), and support mechanisms (25%). Overall, the findings suggest that whilst countries prioritise digitalisation for productivity, costs, and labour, there is growing but uneven recognition of the importance of digitalisation in sustainability, climate resilience, and data-driven agriculture.

Figure 2.4. Needs Areas for Digitalisation by Country



Source: Authors' compilation.

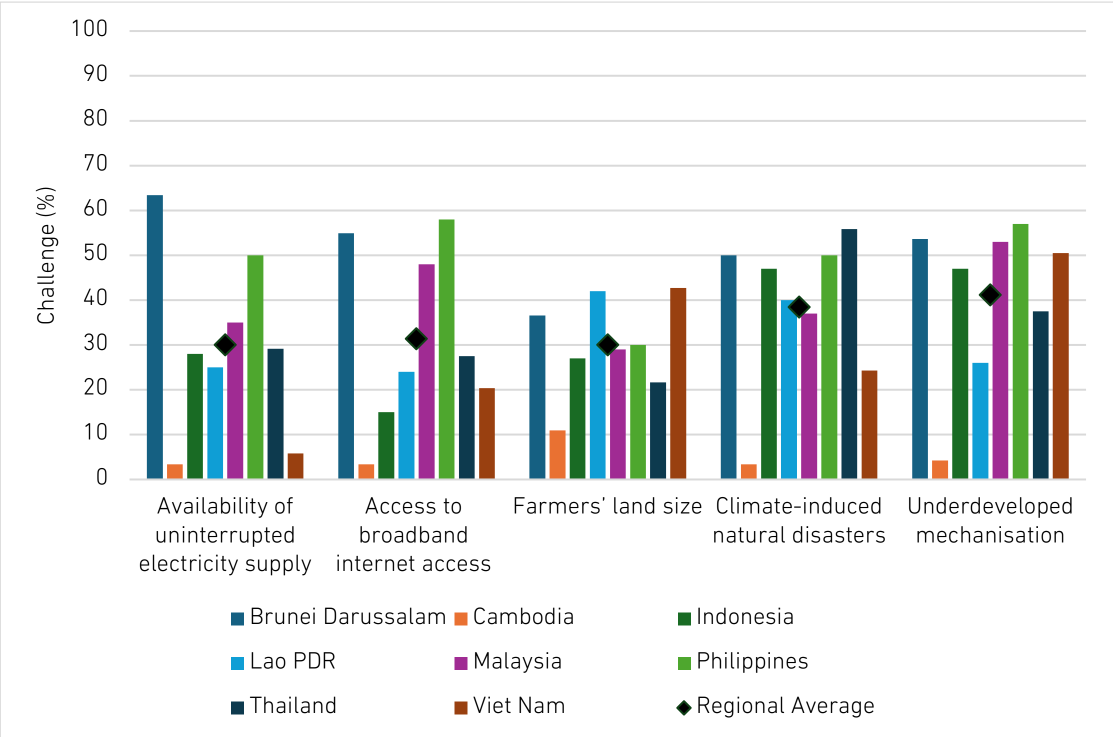
2.3.3 Challenges, Constraints, and Obstacles for Using Digital Technologies and Introducing Digital Solutions

To better understand the challenges, constraints, and obstacles hindering the adoption of digital technologies in agriculture, the survey asked respondents to identify the main challenges and obstacles they face. The question was divided into five key areas: basic infrastructure, human resources, financial aspects, institutional factors, and digitalised data management and information transfer.

2.3.3.1 Basic Infrastructure

The challenges related to access to basic infrastructure are availability of uninterrupted electricity supply, access to broadband internet access, farmers' land size, climate-induced natural disasters, and underdeveloped mechanisation. These challenges and constraints associated with accessibility and affordability to basic infrastructure are shown in Figure 2.5. The findings reveal that inadequate mechanisation is amongst the most frequently cited challenges, with the highest share of responses from the Philippines (57%). Similarly, climate-induced natural disasters were a major concern in Thailand (56%), the Philippines (50%), Brunei Darussalam (50%), and Indonesia (47%), reflecting the region's vulnerability to floods, droughts, and other extreme events.

Figure 2.5. Challenges and Constraints in Basic Infrastructure in Applying Digital Solutions



Source: Authors' compilation.

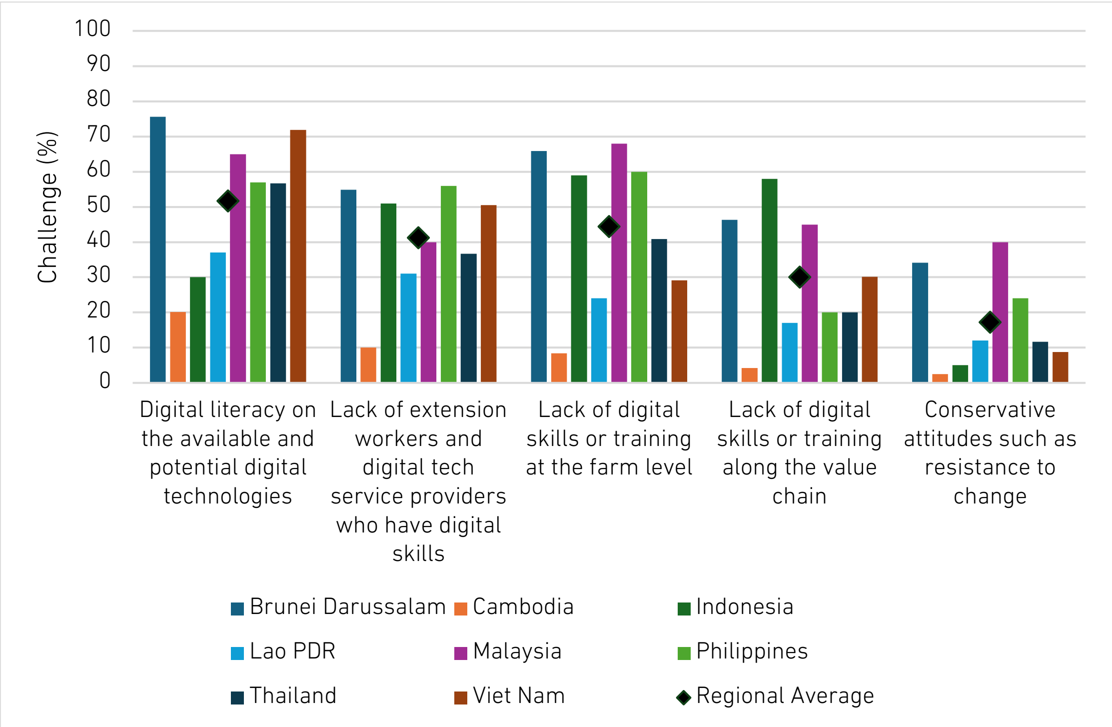
The respondents from Brunei Darussalam highlighted the lack of reliable electricity (63%) and broadband internet access (55%) as significant barriers. The respondents from the Philippines also reported similar concerns, with 50% citing unstable electricity supply and 58% limited broadband coverage. The respondents from Malaysia also noted gaps in broadband internet accessibility.

Smaller farm sizes were considered an obstacle in Viet Nam (43%), Lao PDR (42%), and Brunei Darussalam (37%), where the scale of agricultural activities may limit the cost-effectiveness of digital solutions. On average, across the eight ASEAN countries, the most common challenges identified were underdeveloped mechanisation (41%) and climate-induced natural disasters (38%).

2.3.3.2 Human Resources

The human resource challenges faced by farmers and stakeholders in adopting digital technologies across selected ASEAN countries are shown in Figure 2.6. The results show that limited digital literacy is a widespread constraint, particularly in Brunei Darussalam (76%), Viet Nam (72%), and Malaysia (65%). Similarly, lack of digital skills or training at the farm level was also identified as a major issue in Malaysia (68%), Brunei Darussalam (66%), the Philippines (60%), and Indonesia (59%). Along the value chain, skill shortages were most notable in Indonesia (58%) and Brunei Darussalam (46%).

Figure 2.6. Challenges and Constraints Associated with Human Resources in Applying Digital Solutions



Source: Authors' compilation.

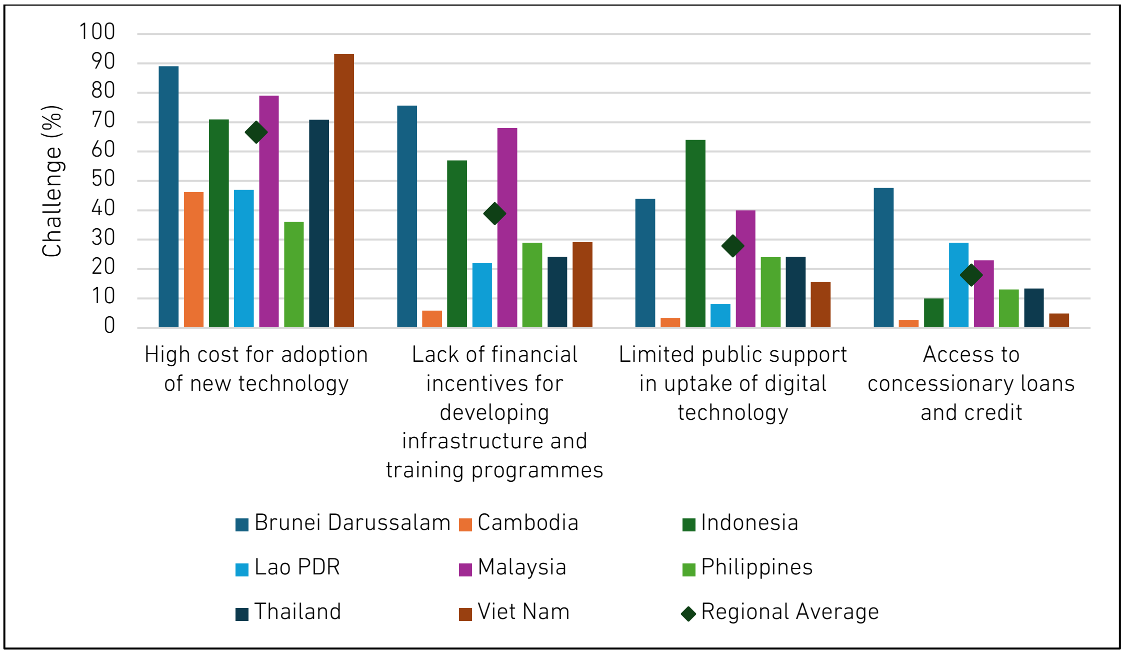
The shortage of extension workers and service providers with sufficient digital skills was another significant barrier, as reported in the Philippines (56%), Brunei Darussalam (55%), Indonesia (51%), and Viet Nam (50%). In addition to these issues associated with capacity development perspectives, conservative attitudes, such as resistance to change, were also noted, with relatively higher response percentages in Malaysia (40%), Brunei Darussalam (34%), and the Philippines (24%). However, this factor was generally less significant compared to digital skill gaps.

On average across the eight ASEAN countries, 31% of respondents identified human resource constraints as a barrier to digital adoption. Amongst these challenges associated with human resource limitations, lack of digital literacy and insufficient training at the farm level were the most prominent, whilst resistance to change was mentioned by only 17%.

2.3.3.3 Financial Aspects

The financial constraints associated with the adoption of digital technologies across the surveyed ASEAN countries are shown in Figure 2.7 as the percentage of responses for each financial challenge. The respondents consistently highlighted key financial challenges, including the high cost of adopting new technologies, limited financial incentives for infrastructure and training, insufficient public support, and restricted access to concessionary loans and credit. There is considerable variation across the selected countries, with some reporting comparatively higher financial barriers than others.

Figure 2.7. Financial Challenges and Constraints in Applying Digital Solutions



Source: Authors' compilation.

Viet Nam reported the highest level of concern regarding the cost of technology adoption (93%), whilst the Philippines reported the lowest (36%). This highlights the disparities in affordability across the surveyed countries. According to the respondents from Brunei Darussalam, the country was identified as the most affected by restricted access to concessionary loans and credit, with 48% respondents indicating this constraint.

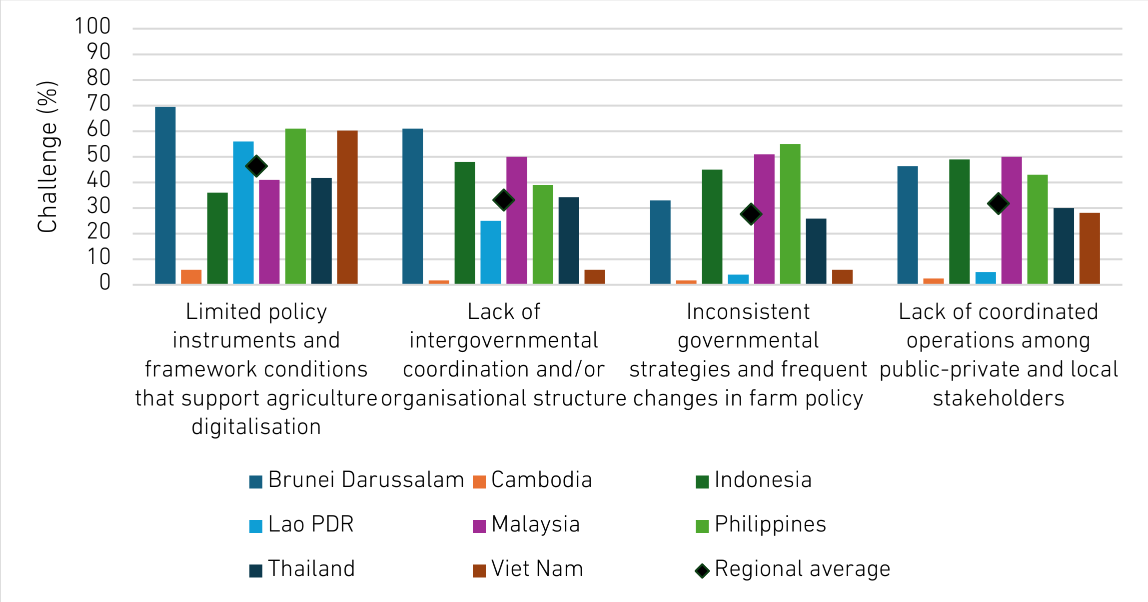
On average, the most critical concern was the high cost of adopting new technologies (67%), followed by the lack of financial incentives for developing infrastructure and training programmes (39%). Amongst other financial challenges and constraints, respondents in Brunei Darussalam identified bankers' unwillingness to provide bank loans to the agricultural sector, citing the risks associated with the field.

2.3.3.4 Institutional Factors

The analysis of institutional barriers to agricultural digitalisation across ASEAN countries reveals significant variation (Figure 2.8). Brunei Darussalam (70%) and the Philippines (61%) reported the highest levels of concern regarding limited policy instruments and framework conditions, whilst Viet Nam (60%) and Lao PDR (56%) also highlighted this as a critical challenge. Lack of intergovernmental co-ordination was most pronounced in Brunei Darussalam (61%) and Malaysia (50%), whereas inconsistency in governmental strategies emerged strongly in the Philippines (55%), Malaysia (51%), and Indonesia (45%). Constraints related to the lack of co-ordinated operations amongst public-private and local stakeholders were noted particularly in Malaysia (50%), Indonesia (49%), Brunei Darussalam (46%), and the Philippines (43%).

On average, the institutional barrier of greatest concern across the eight ASEAN countries was limited policy instruments and framework conditions (46%), followed by lack of intergovernmental co-ordination and/or organisational structure (33%). These findings suggest that whilst advanced technical solutions are addressing most of the constraints associated with the agriculture and food value chain, institutional weaknesses, mainly in policy frameworks and poor public-private collaboration, remain substantial constraints to the effective integration of digital technologies in this field.

Figure 2.8. Institutional Challenges and Constraints in Applying Digital Solutions



Source: Authors' compilation.

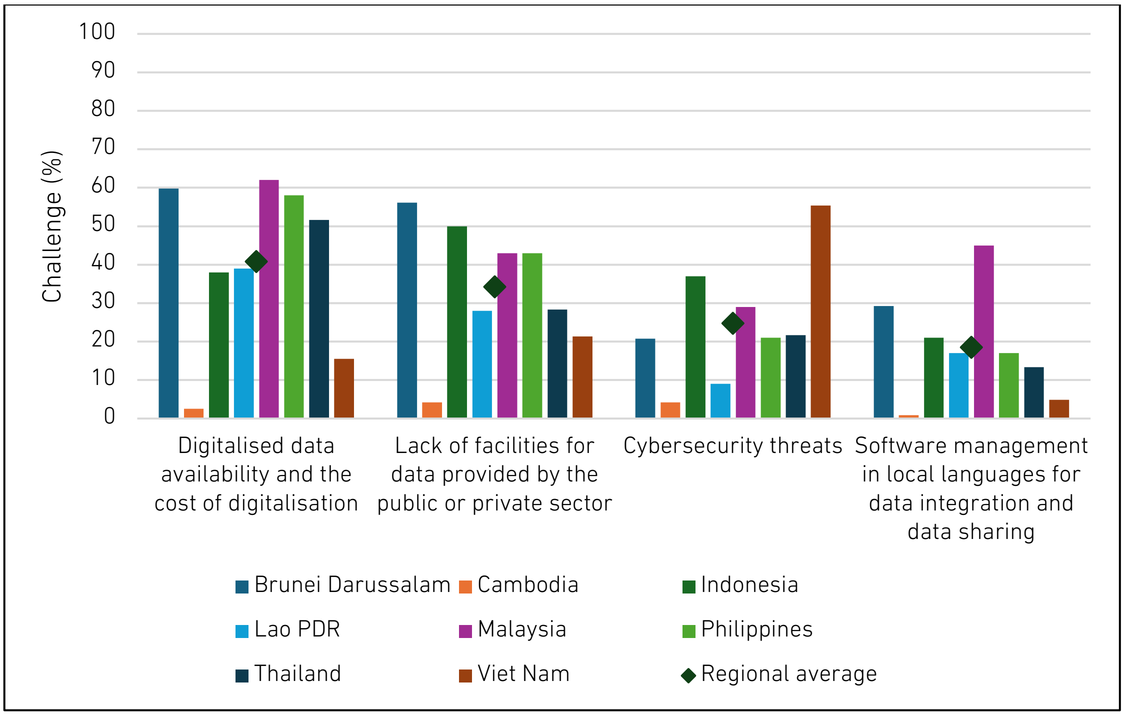
2.3.3.5 Digitalised Data Management and Information Transfer

The analysis of respondents' responses reveals significant variation amongst the selected ASEAN countries regarding the challenges in digitalised data management and information transfer (Figure 2.9). Digitalised data availability and the cost of digitalisation were identified as a critical barrier in these countries, particularly in Malaysia (62%), Brunei Darussalam (60%), the Philippines (58%), and Thailand (52%).

In contrast, cybersecurity threats were most prominently reported in Viet Nam (55%) and Indonesia (37%), reflecting country-specific challenges. The lack of facilities for data provided by the public or private sector was highlighted mainly in Brunei Darussalam (56%), Indonesia (50%), Malaysia (43%), and the Philippines (43%). These findings suggest that whilst all ASEAN countries face challenges in digital data management, the nature and intensity of the challenges and constraints differ, requiring context-specific digital solutions.

The regional assessment reveals that the main barriers to digital technology adoption in agriculture and food value chains are fairly balanced across several dimensions. On average, financial (31%) and human resource (31%) constraints are the most significant challenges, followed closely by limitations in basic infrastructure (30%). Institutional barriers account for 29%, highlighting issues such as policy frameworks and organisational capacity. Meanwhile, challenges related to digitalised data management and information transfer are relatively lower at 24%, though still substantial, particularly in areas concerning data availability, integration, and cybersecurity. This distribution suggests that whilst financial and human capacity constraints are the most critical, all five categories remain critical factors shaping the adoption of digital technologies in the region

Figure 2.9. Digitalised Data Management and Information Transfer Challenges and Constraints in Applying Digital Solutions



Source: Authors' compilation.

2.3.4 Government Support for the Adoption of Digital Technologies in Agriculture

The extent of government support across the selected ASEAN countries varies considerably in terms of financial, technical, and in-kind assistance for the adoption of digital technologies in agriculture and food value chains.

2.3.4.1 Financial Support

On average, only 16% of respondents reported receiving sufficient financial support from the government, whilst 14% indicated receiving insufficient financial support from the government. However, majority, 70%, reported not receiving financial assistance from the government. Amongst the selected ASEAN countries, the Philippines reported a relatively higher level of sufficient financial support, whilst levels remained low in other selected ASEAN countries, such as Cambodia, Indonesia, and Viet Nam (Figure 2.10).

2.3.4.2 Technical Support

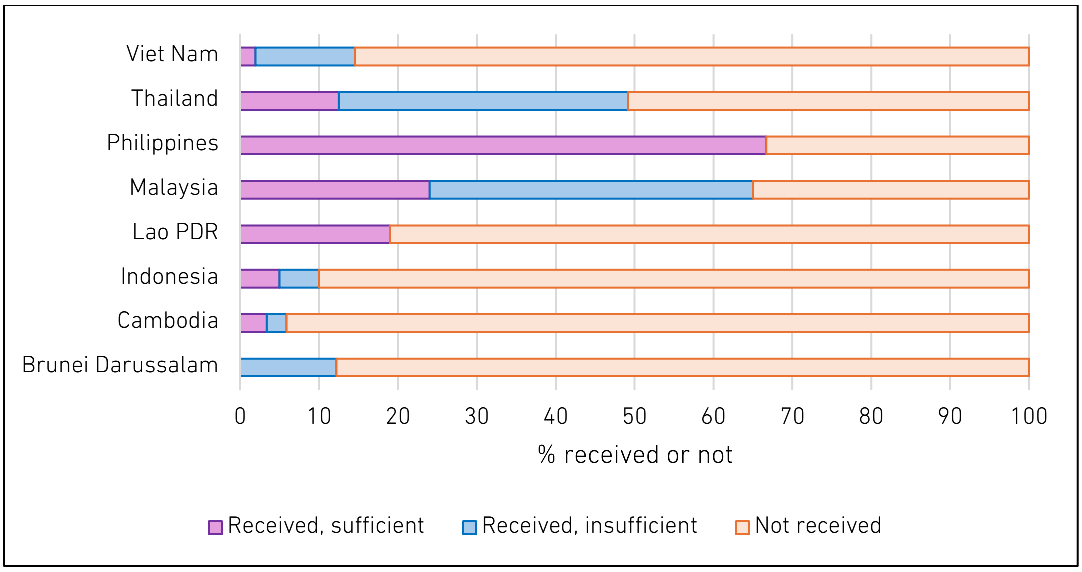
Technical support was more widely available compared to financial support. On average, 23% of respondents reported sufficient technical support, 27% reported receiving insufficient technical support, and 50% reported receiving no support (Figure 2.11). Lao PDR and Thailand showed stronger provision of sufficient technical support, whilst Brunei Darussalam, Viet Nam, and Cambodia recorded much lower levels.

2.3.4.3 In-kind Support

In-kind support was reported to a lesser extent. Only 10% of respondents received sufficient in-kind support, 9% received insufficient support, and the majority reported receiving no in-kind support (Figure 2.12). Lao PDR and Malaysia reflected slightly better access to in-kind support, whilst most other countries showed minimal provision.

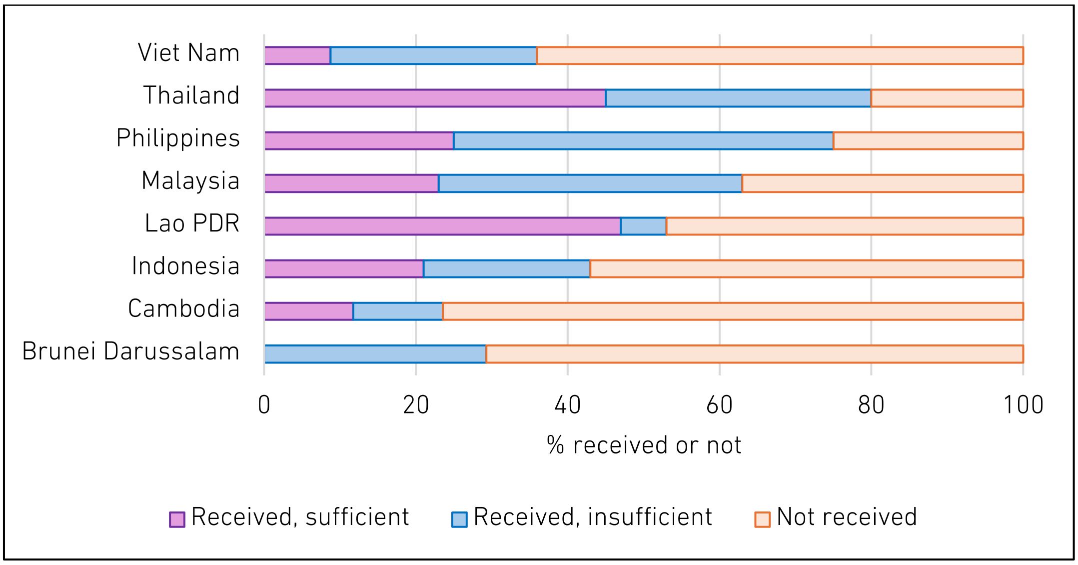
Amongst the countries, Malaysia stands out for having the highest proportion of respondents (52%) reporting that they received in-kind support, which is notably higher than in other countries in the region. However, even in Malaysia, a significant proportion of respondents still indicated that support was insufficient.

Figure 2.10. Financial Support from the Government for the Adoption of Digital Technologies in Agriculture



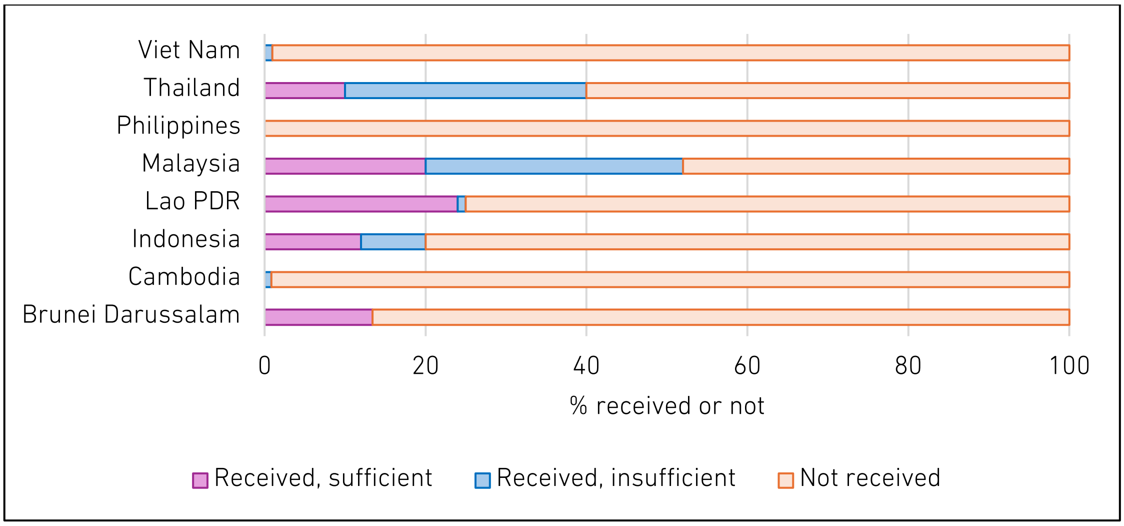
Source: Authors' compilation.

Figure 2.11. Technical Support from the Government for the Adoption of Digital Technologies in Agriculture



Source: Authors' compilation.

Figure 2.12. In-kind Support from the Government for the Adoption of Digital Technologies in Agriculture



Source: Authors' compilation.

Overall, the findings reveal that whilst technical support is relatively more accessible than financial or in-kind support, there remain significant gaps in comprehensive government assistance across the region. The reliance on limited financial and in-kind provisions suggests that more robust and inclusive policies are required to enable the widespread adoption of digital technologies in agriculture.

2.3.5 Country-specific Policies Supporting the Use of Digital Technologies in Agriculture

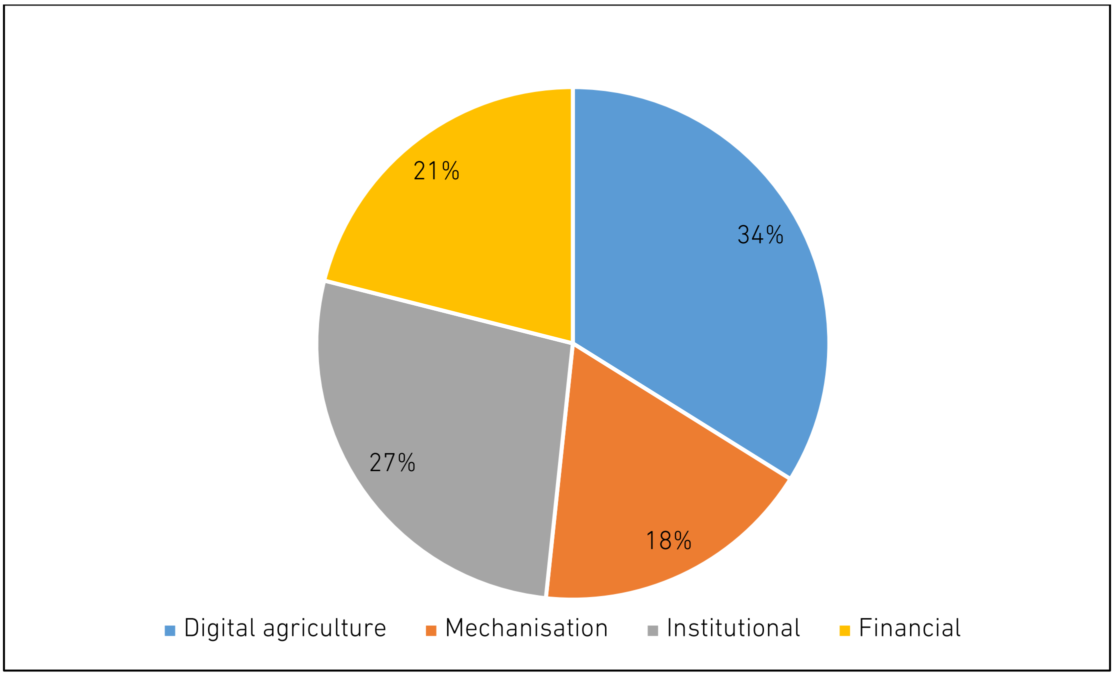
The respondents were asked about their awareness of policies supporting different aspects of agriculture, including digital agriculture, mechanisation, institutional support, and financial support. The findings reveal varying levels of awareness across ASEAN countries. At the regional level, awareness of digital agriculture policies averaged 45%, with respondents indicating familiarity with such policies. This represents 34% of the total respondents who reported awareness of policies across the region, suggesting that digital agriculture is emerging as the most recognised policy area in the agricultural sector (Figure 2.13). High levels of awareness were noted particularly in Cambodia (91%) and Thailand (91%), whilst lower levels were observed in Viet Nam (13%) and Lao PDR (18%).

Awareness of institution-related policies stood at an average of 36% (27% of respondents who reported awareness of policies across the region). Thailand (63%) and Malaysia (52%) showed strong recognition in this category, pointing to more structured institutional backing in these countries.

For financial policies, the regional average awareness was 28% (21% of respondents who reported awareness of policies across the region). Lao PDR (51%), Indonesia (37%), and Brunei Darussalam (21%) were comparatively higher in this category, reflecting a national emphasis on financial mechanisms to support agricultural activities.

In contrast, mechanisation-related policies were the least recognised, with average awareness of 24% (18% of respondents who reported awareness of policies across the region). Malaysia (41%) stood out as the leader in this area, whilst other countries reported minimal recognition. Overall, these results indicate that policy awareness across the region remains uneven, with digital agriculture emerging as the most visible policy domain. However, there are still considerable gaps, particularly in mechanisation and financial policy awareness.

Figure 2.13. Respondents' Policy Awareness by Category



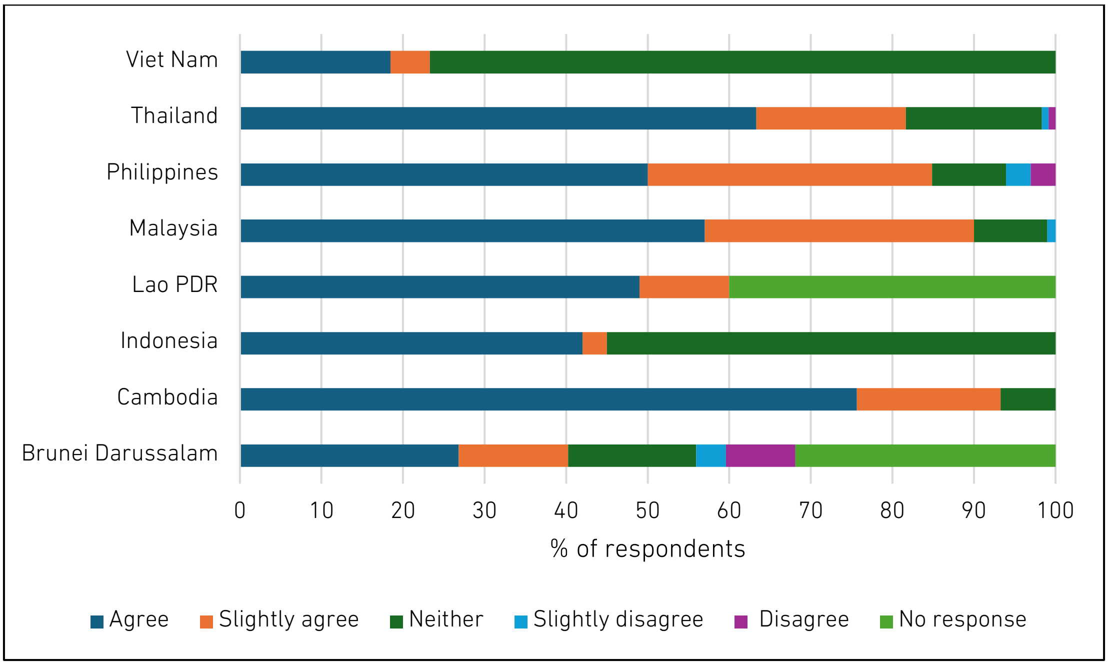
Source: Authors' compilation.

2.3.6 Stakeholder Perceptions of the Supportiveness of Digital Technology Policies

The responses regarding the supportiveness of digital agriculture policies in each country reveal notable variations across the ASEAN region (Figure 2.14). On average, 48% of respondents agreed that digital agriculture policies are supportive, whilst 17% slightly agreed and 24% remained neutral. Only a small proportion of respondents expressed disagreement, with 1% slightly disagreeing and 2% disagreeing, whilst 9% did not respond.

At the country level, Cambodia (76%) and Thailand (63%) recorded the highest levels of agreement, reflecting strong perceptions of supportive policy environments. Malaysia (57%) and the Philippines (50%) also showed majority agreement. In contrast, Viet Nam (77%) and Indonesia (55%) had the highest shares of neutral responses, indicating uncertainty or mixed experiences regarding policy supportiveness. Brunei Darussalam (32%) and Lao PDR (40%) reported relatively high non-response rates, suggesting limited exposure to or awareness of such policies.

Figure 2.14. Policy Supportiveness Perceptions



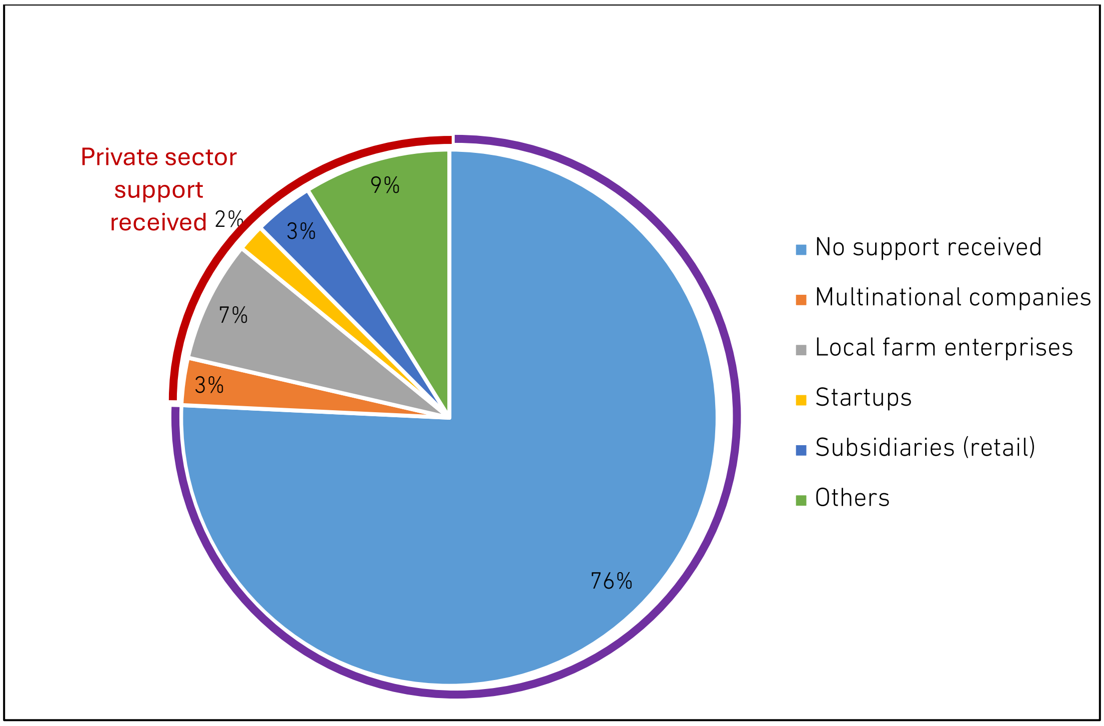
Source: Authors' compilation.

Overall, the findings suggest that whilst there is a generally positive perception of digital agriculture policies across the region, the level of policy supportiveness is uneven, with stronger recognition in some countries and weaker or more uncertain perceptions in others.

2.3.7 Engagement and Support from the Private Sector in Facilitating Digital Transformation in Agriculture and Food Value Chains

Private sector engagement in the utilisation of digital technologies and tools in agricultural production and along food value chains was limited at the regional level. Around 24% of respondents confirmed receiving support from the private sector, whilst the remaining 76% did not (Figure 2.15). Amongst those who received support, the largest share of responses came from local farm enterprises (7%) and other sources, such as research institutions and universities (8%). This indicates that support is not limited to traditional agriculture stakeholders but also comes from a broader set of actors. Smaller proportions of support were attributed to multinational companies (3%), startups (2%), and subsidiaries of retail companies (4%). Country-level data analysis shows that Lao PDR reported the highest level of support from local farm enterprises, whereas other countries received less than 5% support, except for Indonesia (11%). Malaysia reported 41% support from IoT service providers, suggesting reliance on non-traditional or community-driven services.

Figure 2.15. Private Sector Engagement in the Utilisation of Digital Technologies and Tools in Agricultural Production and Along the Food Value Chain

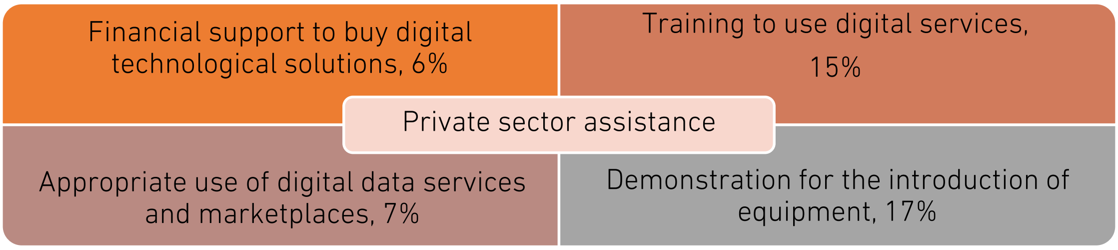


Source: Authors' compilation.

Figure 2.16 provides further insights into the specific types of support provided. Respondents highlighted a diverse range of assistance, most commonly demonstrations for the introduction of equipment (Malaysia, 29%; the Philippines, 32%; Cambodia, 18%) and training on the use of digital services (Lao PDR, 33%; the Philippines, 25%). Financial support for purchasing digital technology solutions was less frequently reported, although some selected countries, such as the Philippines (16%) and Lao PDR (12%), registered relatively high levels. Additionally, Malaysia and the Philippines received support for the appropriate use of digital data services and marketplaces.

Whilst private sector involvement in supporting digital agriculture remains limited across ASEAN, existing engagement is largely concentrated on training, demonstrations, and knowledge-sharing initiatives, with relatively limited provision of direct financial assistance. This indicates that the private sector is playing a more facilitative and enabling role, building capacity, familiarising farmers with new tools, and linking them to markets, rather than serving as the primary financier of digital adoption.

Figure 2.16. Major Types of Private Sector Assistance



Source: Authors' compilation.

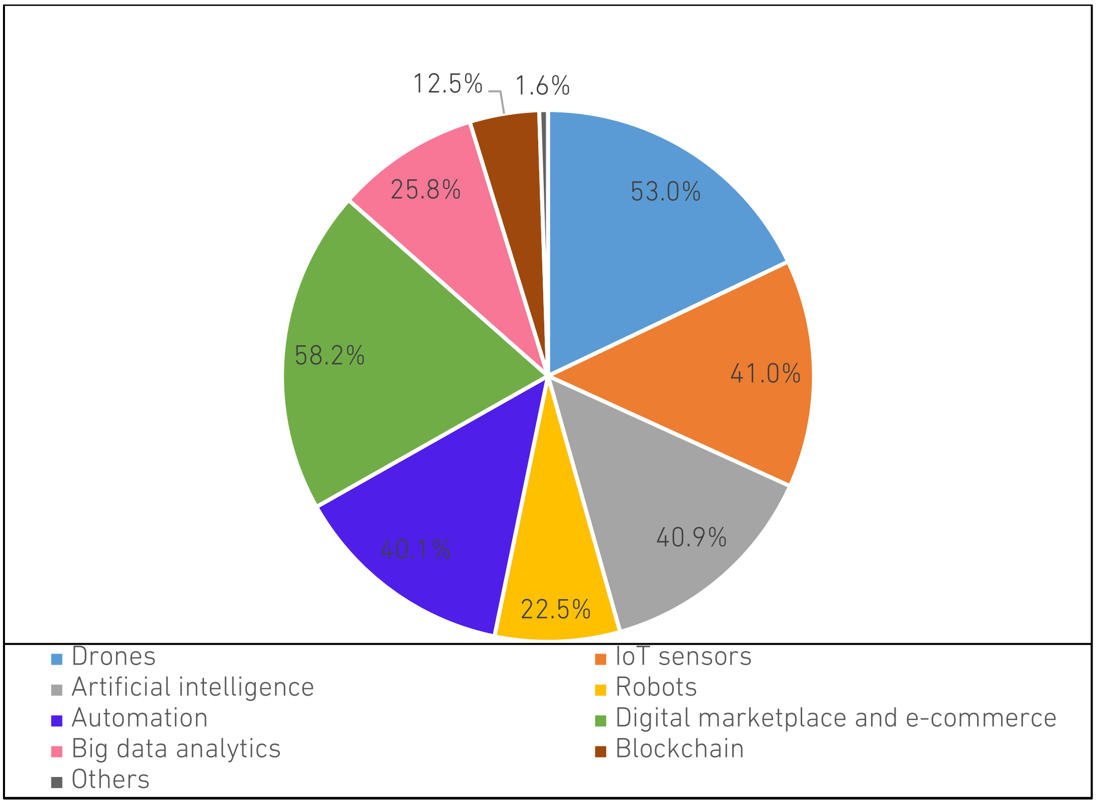
2.3.8 The Future of Digitalisation in Agriculture

Across the selected ASEAN countries, the digital marketplace and e-commerce (58%), drones (53%), IoT sensors (41%), AI (41%), and automation (40%) were identified as the technologies in highest demand (Figure 2.17). Respondents' perceptions of which digital technologies can make a mid- to long-term impact on agriculture and food value chains in the eight selected ASEAN countries are shown in Figure 2.18.

Respondents in Brunei Darussalam highlighted automation and IoT sensors as transformative technologies for the future of digitalisation in agriculture. In Cambodia, drones (72%) dominated responses, whilst respondents in Lao PDR emphasised the digital marketplace (80%) and AI (58%). In Malaysia, the expected impact was more balanced, with AI (52%), IoT sensors (50%), and the digital marketplace and e-commerce (50%) receiving similar levels of attention. The Philippines placed the strongest emphasis on the digital marketplace and e-commerce (78%), whilst in Viet Nam, drones (78%) were seen as particularly impactful.

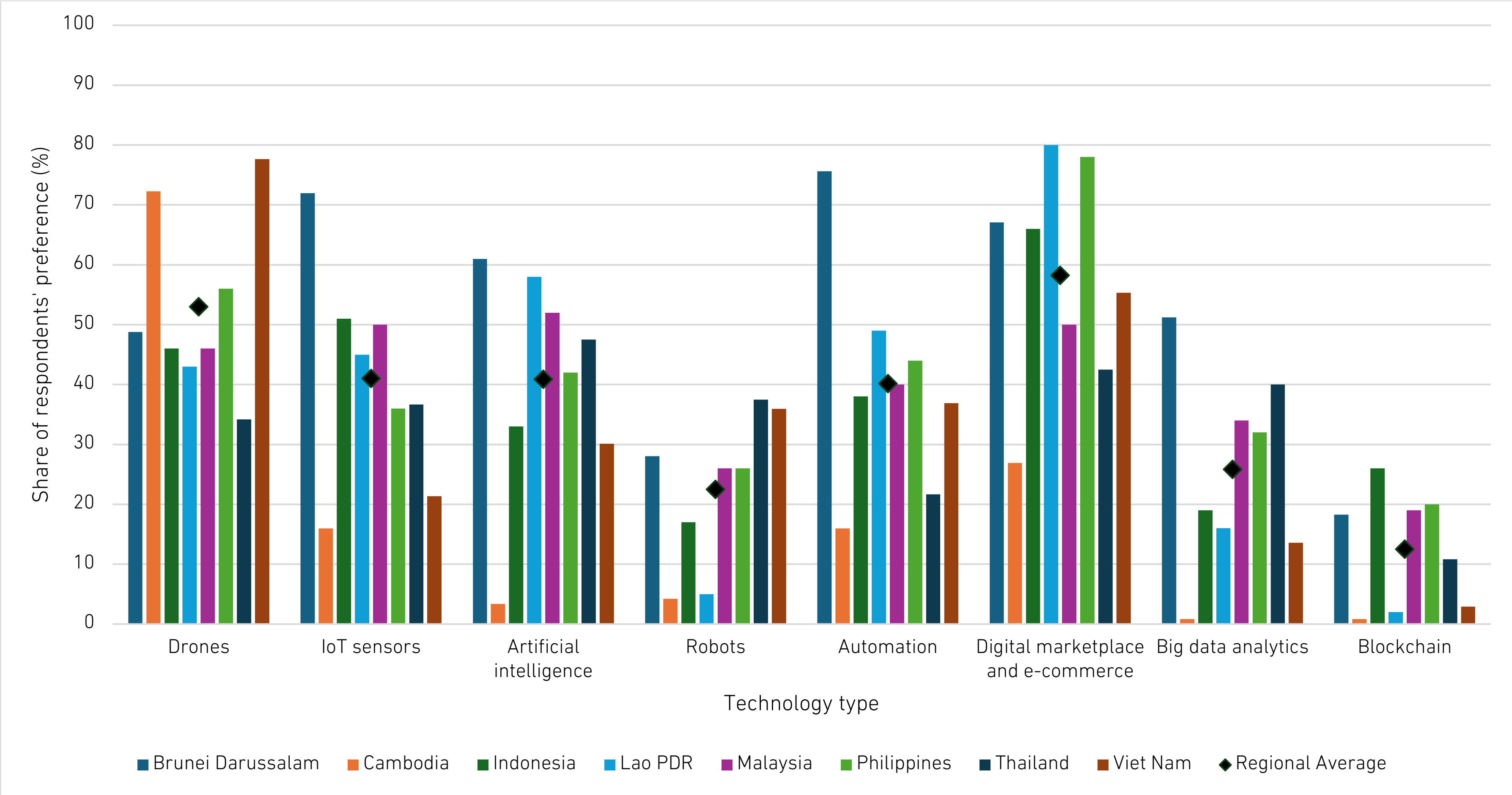
Overall, the results suggest that the digital marketplace and e-commerce are considered the most transformative technologies across ASEAN, followed closely by IoT sensors and AI. However, the country-level responses also show diverse priorities, reflecting local agricultural needs and different stages of digitalisation across ASEAN.

Figure 2.17. Respondents' Average Perceptions of Expected Digital Technologies in the Region



Source: Authors' compilation.

Figure 2.18. Respondents' Perceptions of Expected Digital Technologies in the ASEAN Region by Selected Country



Source: Authors' compilation.

2.4 Overall Findings

Across ASEAN countries, current digital agriculture practices show moderate adoption in production technologies (regional average: 14%), distribution and financing tools (31%), and digital traceability systems (11%), with notable variation across countries and technologies.

Across ASEAN countries, the most pressing needs in agriculture are increasing production and productivity (65%), reducing costs (67%), and adopting labour-saving methods (56%), whilst comparatively lower emphasis is placed on data management (29%), applying support services (25%), and other needs (3%).

According to this study, the main challenges in the implementation of digital agriculture faced by key players in agricultural value chains consist of:

1. High costs of technology adoption
2. Low digital literacy and a lack of skilled extension workers
3. Infrastructure limitations
4. Institutional and policy fragmentation
5. Smallholder structures that limit scalability

Moreover, the study identifies a fundamental obstacle: a dual deficiency in digital (broadband internet) and physical (mechanisation) infrastructure. Additionally, it highlights the critical point that the lack of digital skills is not just a deficiency amongst farmers but rather reflects a systemic failure in the agricultural support system, as extension workers themselves often lack digital proficiency.

Government initiatives in ASEAN countries show that most respondents report insufficient or no support, with limited sufficient assistance in financial (17%), technical (23%), and in-kind (10%) forms, highlighting significant gaps in effective delivery. Across ASEAN countries, private sector support received by respondents averages 24%, with country-level values ranging from 5% in Viet Nam to 41% in Lao PDR and Malaysia, indicating generally low to moderate engagement from the private sector.

Respondents' views on policy support indicate mixed perceptions. Whilst nearly half (48%) agree that policies at the country level support their activities, a substantial share remains neutral (24%) or reports slight agreement or disagreement (20%), suggesting that policy alignment with stakeholders' needs is perceived as moderate across ASEAN countries.

The disparity between farmers' high adoption of information-based basic tools (such as farming advisory apps) and their extremely low adoption of capital-intensives technologies (such as AI, robotics, and IoT sensors) is an important finding. This is explained by risk aversion and the substantial initial outlay needed for complex hardware-based solutions. According to future projections, e-commerce and the digital marketplace are expected to have the most significant impact, with an average of 58%, reflecting stakeholders' strong desire for direct and effective market access.

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Chapter 3

Digitalisation in Agriculture and Food Systems for Resilience and Sustainability in Brunei Darussalam

Rose Abdullah, Nur Thaqifah Salihah Mohd Salleh, Mohamed Najim Mohamed Mujithaba, Ahmed Osumanu Haruna, and Tiawa binti Awang Haji Hamid

3.1 Introduction

Brunei Darussalam has embarked on a strategic journey to modernise its agriculture sector by leveraging digital technologies. These advancements aim to improve productivity, ensure sustainability, and increase resilience across various agricultural subsectors (Food and Agriculture Organization of the United Nations [FAO], 2022; Department of Agriculture and Agrifood, 2021; Prime Minister's Office, 2020).

The initial adoption of digital technologies in Brunei Darussalam's agriculture sector was more pronounced in the agriculture, aquaculture, poultry, and livestock subsectors. Aquaculture was amongst the early adopters of digital technologies, such as Internet of Things (IoT) sensors for water quality monitoring, automated feeding systems, and remote surveillance and environmental control tools. Faster adoption in this subsector was due to its high value and measurable return on investment. This subsector also receives government support, as the government aims to increase fish production for local and export markets (Rahman and Bakar, 2022).

Other subsectors that have responded more quickly to digitalisation are poultry and livestock, especially using automated feeding and climate regulation systems, sensor-based livestock health monitoring, and digital record-keeping for breeding and productivity analysis. This early adoption was due to a scalable production environment suitable for automation and a strong need for biosecurity and efficiency improvements (FAO, 2022).

It is important to understand the status of digital technology practices across the agriculture value chain. Literature reviews show that digital solutions are being integrated across the full spectrum of the agriculture value chain, including the production phase, post-harvest handling and processing, marketing and distribution, and support and advisory services.

In the production phase, farmers commonly use digital technologies such as precision agriculture tools, including drones and smart irrigation; IoT-based monitoring for soil, temperature, and humidity; and controlled-environment agriculture, such as hydroponics and smart greenhouses (FAO, 2022). Common digital technologies in the post-harvest handling and processing phase include cold chain and logistics monitoring, automated sorting, grading, and packaging, and traceability systems using QR codes or blockchain (ASEAN Secretariat, 2021). Marketing and distribution activities use e-commerce platforms and agri-marketplaces, social media and digital branding tools, and online transaction systems for direct-to-consumer sales (Prime Minister's Office, 2020). In addition, various support services are available to facilitate the use of digital technology, including mobile apps that offer weather forecasts, pest alerts, and market prices. Advisory services are normally provided through virtual training and digital extension services for farmers, whilst fintech solutions support microloans and crop insurance services (FAO, 2022).

3.2 Method

3.2.1 Data Collection

Data were collected through personal surveys using a structured questionnaire. These were conducted in several ways. Most surveys were conducted through individual interview surveys, whilst two focus group discussions were held, consisting of three and four respondents per group. Some respondents requested to complete the questionnaire themselves. The surveys were conducted in either English or Malay, depending on the respondents' preferences. To ease the process of data collection and data entry, the questionnaires were converted into Google Forms. The enumerators entered the data directly into the Google Form during the interviews. In these cases, the enumerators conducted the interviews in pairs: one partner conducted the interview, whilst the other entered the data. However, some enumerators preferred to use printed questionnaires and enter the data after the interviews.

3.2.2 Key Informants

Information on users of digital technologies in agriculture and food systems was provided by the Department of Agriculture and Agribusiness (DoAA) and the Department of Fisheries, Brunei Darussalam.

The list of targeted respondents was provided by the two departments mentioned above and, with snowball sampling, totalled 140 potential respondents. The locations of the potential respondents covered four districts of the country. However, the researchers only managed to interview 82 respondents. The proportion of respondents, as well as the commodity composition, is discussed in the data analysis and interpretation section. The initial focus was on farmers producing crops, and this was later extended to aquaculture, agri-food processors, and technology providers. Most respondents were in Brunei Darussalam's Muara District, as more Agriculture Development Areas (ADAs) designated for farmers are in this district (DoAA, 2023). The respondents consisted of actors across the agricultural value chain, including farmers, distributors, agribusiness enterprises, and other relevant stakeholders who had already utilised digital agriculture technologies in their operational activities. The selected respondents were also key stakeholders involved in agriculture and food supply chains in Brunei Darussalam.

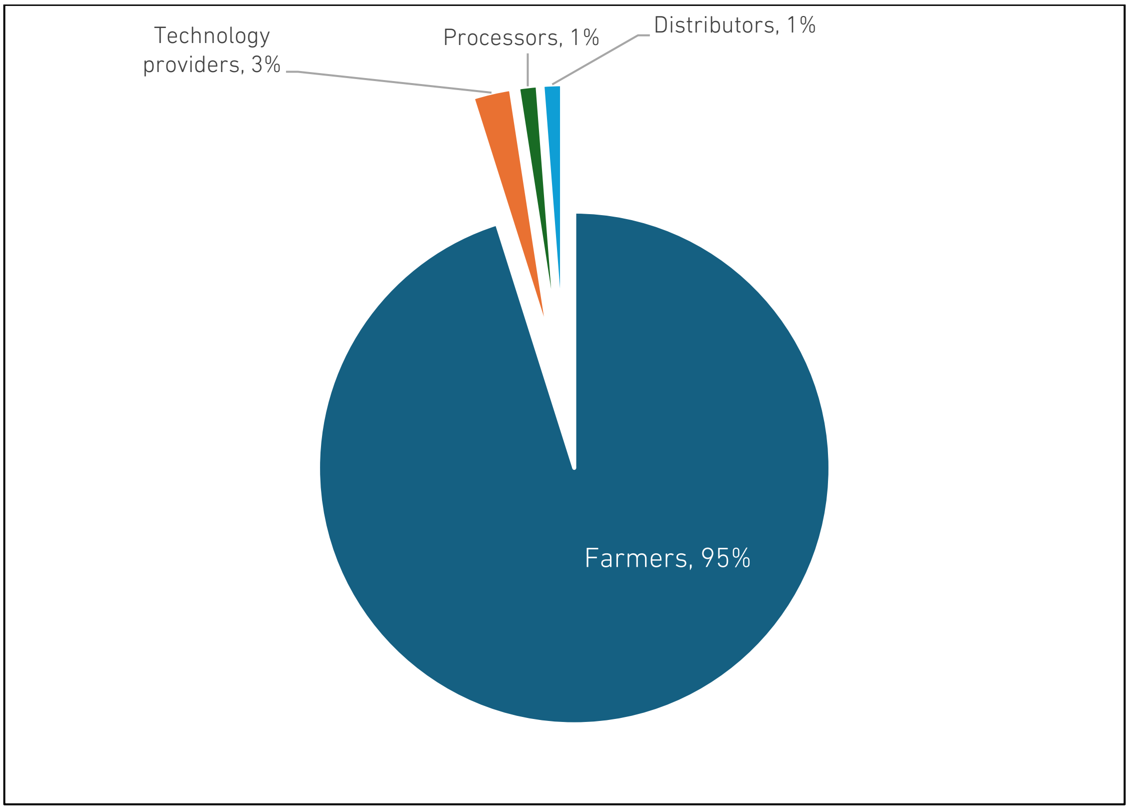
As not all potential respondents were engaged in digital practices within their agricultural activities, a certain segment was excluded from the study. Additionally, some respondents expressed reluctance to participate in the interview for various reasons. Despite these challenges, the country researchers successfully interviewed 82 respondents by 26 May 2025. The data collection process spanned approximately two and a half months.

3.3 Data Analysis and Interpretation

3.3.1 Profile of Respondents

There were 82 total respondents. The majority of the respondents were farmers (95%), whilst the rest comprised technology providers (3%), processors (1%) and distributors (1%) (Figure 3.1).

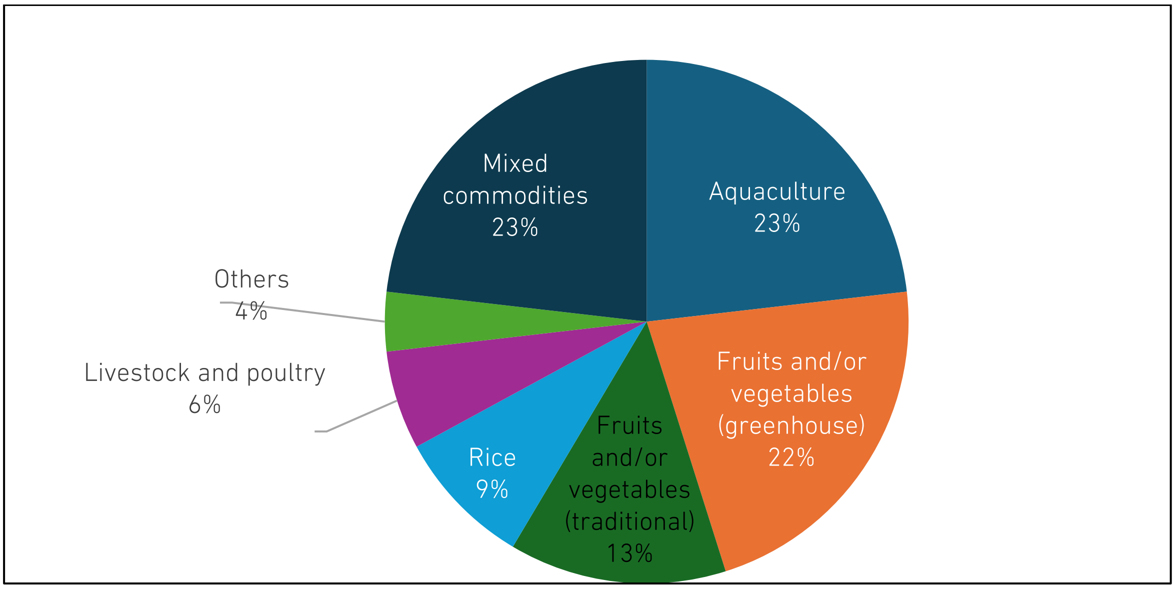
Figure 3.1. Category of Respondents Involved in the Survey



Source: Authors.

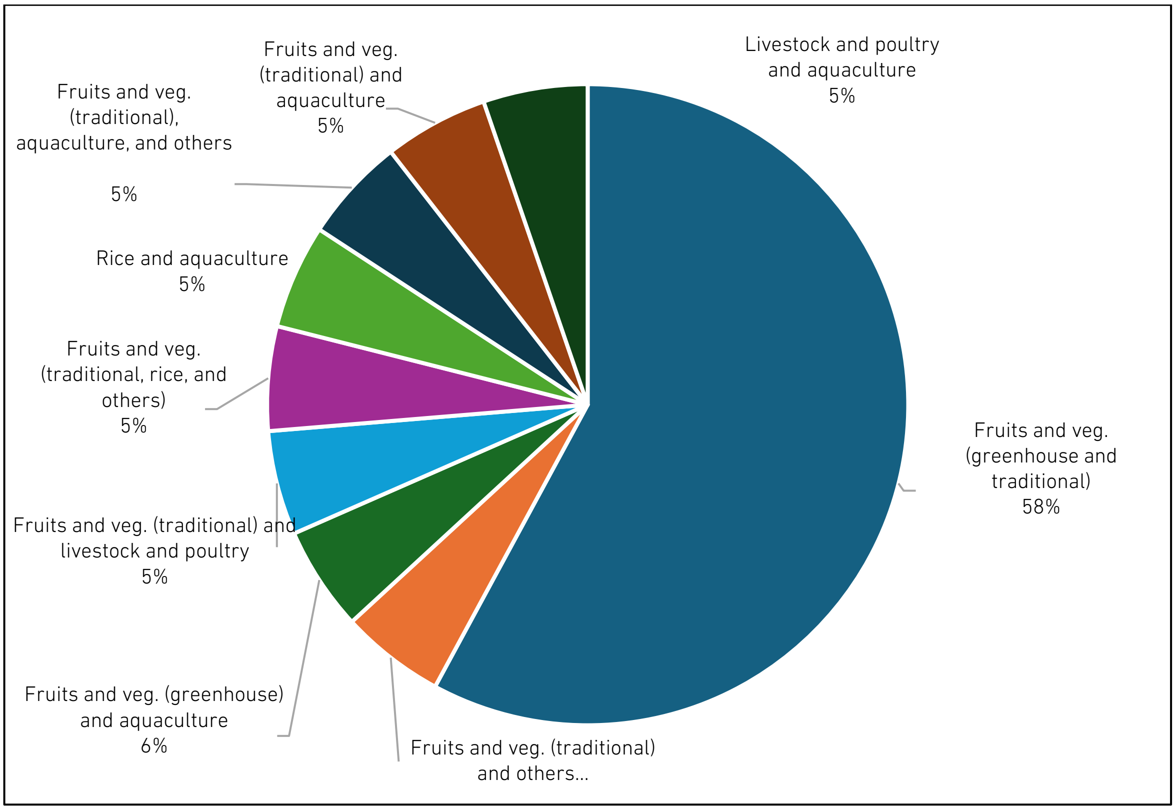
In terms of commodities, the most common main commodity amongst the 82 respondents was aquaculture, at 23%. This was followed closely by fruits and/or vegetables grown using greenhouses and mixture of commodities, both at 22%. The breakdown of the mixture of commodities can be seen in Figures 3.2 and 3.3, with other commodities including agarwood production, agricultural machinery and agricultural inputs. Fruits and/or vegetables grown using traditional methods accounted for 14%, rice for 9%, and livestock and poultry for 6%. In addition, 4% of respondents selected 'others', which included agriculture and service providers, as well as agricultural input suppliers (Figure 3.2 and Figure 3.3).

Figure 3.2. Shares of Types of Commodities of the Respondents



Source: Authors.

Figure 3.3. Shares of Mixed Commodities of the Respondents



Source: Authors.

The experience levels of agriculture and food businesses are mostly at early to mid-level, with 30.4% of companies having less than 5 years of experience, 43.9% having 5–10 years of experience, and 15.9% having 11–20 years of experience in the agriculture and food industry. Only 9.8% of mature companies have more than 20 years of experience (Table 3.1). This can be attributed to the increase in ADA lands allocations to farmers, from 3,189.80 hectares (ha) in 2020 to 3,763.87 ha in 2024 (DoAA, 2019; 2023). The respondents were mainly male, at 87%, and 76% had an education level of diploma or higher (Table 3.1).

Table 3.1. Socio-Demographic Characteristics of Respondents

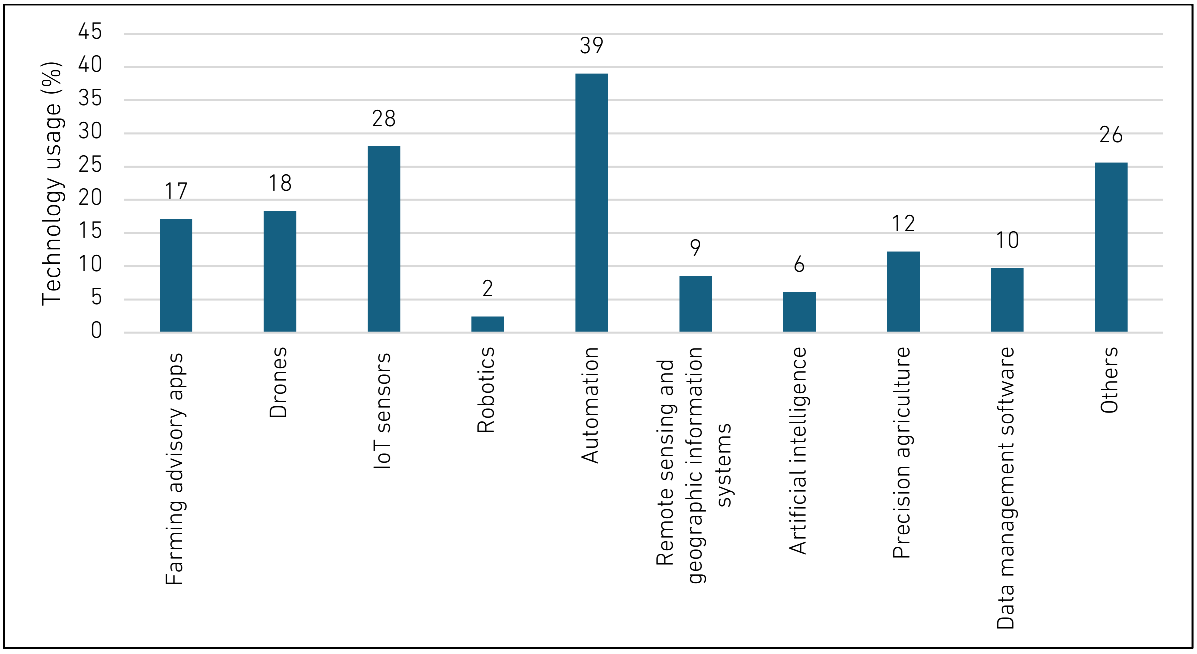
Variable	No. of respondents	Share (%)
Experience level		
<5 years	25	30.4
5–10 years	36	43.9
11–20 years	13	15.9
>20 years	8	9.8
Gender		
Male	71	87
Female	11	13
Education		
Primary	2	2.43
Secondary	14	17.1
Vocational degree	4	4.9
Higher education (diploma or higher)	62	75.6

Source: Authors.

3.3.2 Analysis of the Current Status

The current status of digital technology usage in Brunei Darussalam reveals that respondents primarily employ digital platforms for distribution, marketing, and financing purposes. Notably, 46% utilise digital marketplaces, whilst 54% engage in digital payment systems for banking activities, including transactions with bankers, suppliers, and buyers (Figure 3.4). This can be attributed to the prevalent use of social media in the country, with 64.4% of the total population recorded as social media users in 2025 (We Are Social and Meltwater, 2025). This is especially true for young entrepreneurs, who use social media to market and distribute their products (Hashim et al., 2021). Additionally, online banking has become more prevalent through the introduction of banking apps that make it easier to carry out online payments, coupled with Brunei Darussalam's high mobile phone usage, at 134% of the population (Baiduri Finance, n.d.; BIBD, n.d.; Digital Economy Council, 2024).

Figure 3.4. Digital Production Technology Usage of the Respondents



Source: Authors.

However, production technologies are not yet highly prevalent, although some are used more widely than others, namely automation (39%) and IoT sensors (28%). Others are used by only a few respondents, such as farming advisory apps (17%), drones (18%), and precision agriculture (12%). Data management software is also not prevalent, at 9.8%, followed by geographic information systems (GIS) (8.5%), artificial intelligence (AI) (6.1%), and robotics (2.4%). Other highly used technologies include automated fertigation, feeding, and irrigation.

In terms of digital traceability, limited use was observed. The only tool used was barcode or QR codes to identify information or support retail point-of-sale systems. About 83% of respondents perceived the need for greater use of digital technologies to improve various parts of the supply chain, especially to increase agricultural production and productivity. Other major areas perceived as requiring improvement through digital technologies are as follows:

- Reducing production/operation costs (68%)
- Enhancing farm produce quality (65%)
- Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding (63%)
- Exploring new marketing opportunities (61%)
- Data management (56%)
- Mitigating the impacts of climate change (55%)
- Dealing with labour shortages (55%)
- Reducing post-harvest loses (52%)
- Applying for support, such as subsidies and insurance (51%)

However, the majority of respondents did not see the importance of leveraging digital technologies for more environmentally friendly agriculture (33%), assuring consumers of origin and quality (39%), or increasing food safety (44%). Respondents also pointed to the use of digital technologies in agriculture in the following areas:

- Increasing farm security
- Forecasting production and supply
- Providing online information on market demand and centralised information on farm outputs for improved price expectations and cost control
- Disease control

According to the respondents' views, implementation challenges related to infrastructure for digital technologies in agriculture and food systems in Brunei Darussalam include uninterrupted electricity supply, which was seen as a major issue, with 63% agreement. However, respondents were more divided on other infrastructure issues, such as the availability of internet connectivity (55% agreement) and underdeveloped mechanisation (54% agreement). This is despite concerted efforts, including the establishment of Unified National Networks Sdn Bhd (UNN) in 2018 and the consolidation of network infrastructure under UNN in 2019 to fast-track digital connectivity in Brunei Darussalam (UNN, n.d.), as well as the reduction of customs import and excise duties on industrial machinery and spare parts for heavy vehicles to 0% and 2.5%, respectively, through the Customs Import and Excise Duty Amendment Order 2017 (Ministry of Finance, 2017). Respondents were also divided on climate-induced disasters, with 50% agreeing that they are a challenge to the implementation of digital technologies in agriculture and food systems in Brunei Darussalam. However, land size was not seen as a major obstacle, as only 37% agreed that it was an issue, with some expressing the opinion that better support was needed to implement digital technologies effectively.

In terms of human resources, views were divided on the challenges of implementing digital technologies in agriculture and food systems. Some 55% of respondents agreed that this was due to a lack of extension workers, whilst 66% at the farm level and 46% along the value chain agreed that it was due to a lack of digital skills at the farm level and along the value chain. This could be attributed to limited digital literacy regarding what is available for agriculture and food systems (76%). There was also a smaller group who believed that conservative attitudes toward the use of digital technologies, especially amongst older farmers, posed a challenge (34%).

Nevertheless, 89% of respondents stated that the major constraint to adopting digital technologies in agriculture and food systems was the high cost. This was especially the case since respondents agreed that there were no financial incentives to develop infrastructure or provide training in the use of digital infrastructure (76% agreement). However, opinions on public support and access to loans and credit were divided, with 44% and 48% agreement, respectively. It should be noted that the profitability of taking such loans remains questionable.

At the institutional level, there was general agreement regarding the lack of government intervention and the disorganised organisational structure of government, at 70% and 61%, respectively. In terms of data management, cybersecurity and language barriers were not seen as major issues for digital technology implementation. However, the lack of data facilities, such as those for market information (56% agreement), and digitalised data availability and the cost of digitalisation (60% agreement) were seen as more significant issues.

3.4 Overview of Policies, Government Initiatives, and Programmes for Promoting the Utilisation of Digital Technologies in Agriculture and Food Systems

There are three well-known programmes, policies, and initiatives provided by the Government of Brunei Darussalam, as follows:

1. Authority for Info-communications Technology Industry (AITI) programmes (pilot programmes, smart farming, and smart aquafarm initiatives)
2. Darussalam Enterprise (DARe), under the Brunei Darussalam Economic Development Board, which provides a co-matching scheme for starting farms and funding to adopt agricultural technologies
3. The Digital Economy Master Plan

However, only a small fraction of respondents were aware of these programmes, policies, and initiatives. The data showed that 26% knew about AITI, 21% about DARe, and 9% knew about the Digital Economy Master Plan. As a result, some respondents abstained from answering Question 6 regarding the effectiveness of the programmes, with only 51 out of 82 respondents providing an answer. Of these 51 respondents, 33 agreed or slightly agreed, 10 slightly disagreed or disagreed, and 8 mentioned neither.

Other initiatives to note include the establishment of Bank Usahawan in 2017, which was specifically established to meet the financial needs of micro, small, and medium-sized enterprises in Brunei Darussalam, including loans for adopting digital technologies (Bank Usahawan, n.d.), and DoAA pilot projects, where ADA land is allocated for high-technology farming.

Table 3.2. Respondents' Perspectives on Government Support (%)

	Financial support	Technical support	In-kind support
No	72	58	71
Yes, sufficient	0	0	11
Yes, insufficient	10	24	0

Source: Authors.

Table 3.2 shows the respondents' responses regarding government financial, technical, and in-kind support. Most of the respondents (71%–88%) did not receive any of these forms of support in adopting technology in agriculture. Small shares of respondents received financial and technical support, at 12% and 30%, respectively, but indicated that the support was insufficient. Only in terms of in-kind support did 13% of respondents report that they had received sufficient support.

3.5 Challenges and the Way Forward

The primary challenge in the adoption of digital technologies in agriculture lies in the substantial initial investment required. Consequently, numerous farmers are reluctant to embrace these advancements, primarily due to constrained capital resources, particularly amongst smallholder farmers. Therefore, the data collected showed the need for stronger digital infrastructure in rural areas, and this is supported by literature information from the Department of Agriculture and Agrifood (2021). Thematically, the challenges can be viewed in terms of financial accessibility, physical accessibility, access to expertise, and bureaucracy.

3.5.1 Financial Accessibility

The high upfront costs of digital technologies (IoT, drones, and smart sensors) are especially difficult for smallholder farmers. Traditional loan structures may not match the agricultural cash flow cycle, which can lead to repayment difficulties. Investment in digital technology in agriculture involves a long-term return on investment, which creates hesitation amongst farmers with limited capital.

Therefore, the researchers recommend that financial institutions revise loan repayment schedules to align with harvest cycles (e.g. lump-sum payments that can be made post-harvest instead of as monthly instalments) or provide seasonal loan structures. The government and financial institutions could also offer co-financing schemes or targeted subsidies for technology adoption. Other options could include technology leasing or shared ownership models through co-operatives or agri-tech service providers to offer digital tools on a rental or subscription basis.

3.5.2 Physical Accessibility

Many farmers facing difficulties accessing retailers or distributors for agricultural technology or essential farming inputs, such as feed, fertiliser, tools, and other items. Some inputs are not available in the country, requiring farmers to obtain them from neighbouring countries or other countries. In addition, farmers are preoccupied with daily operational tasks, leaving little bandwidth for technology exploration or adoption. Consequently, strengthening supply chains could be beneficial by optimising logistics and distribution networks for agricultural inputs, thereby alleviating farmers' burdens and freeing up resources for technological integration.

3.5.3 Access to Expertise: Technical Support and Maintenance

Farmers lack training in maintenance and repair of digital tools and equipment. Furthermore, after-sales support and technical assistance are often unavailable or unreliable. These challenges often lead to the abandonment of equipment after malfunctions. Therefore, training local youth as certified agri-tech service agents who can offer maintenance and technical guidance would be a useful strategy for Brunei Darussalam when the adoption of certain types of technology becomes more widespread in the future. Technology providers can also offer modular and user-friendly technologies to promote the adoption of scalable, plug-and-play technologies with minimal setup and low technical requirements.

3.5.4 Streamlining Bureaucratic Processes

Small and medium-sized enterprises struggle due to limited staff capacity to deal with bureaucracy. There is a need to simplify application procedures. Tiered regulatory requirements could be implemented, whereby small-scale farmers or startups are offered expedited or simplified application processes.

In addition to the above matters, available digital solutions are often not tailored to local contexts or are too costly or complex for small and medium-sized enterprises. Investment in research and development for local needs is critical to encourage the digitalisation of agriculture in the country. Collaboration amongst local universities and agri-tech startups to develop modular, affordable, and regionally relevant technologies is relevant in this regard. Service providers can test new solutions in different farming environments to collect feedback and refine usability before large-scale rollouts.

3.6 Conclusion

Brunei Darussalam is steadily integrating digital technologies across its agriculture sector, with aquaculture and livestock emerging as early leaders (Rahman and Bakar, 2022). Continued investment in infrastructure, capacity building, and innovation will be essential for scaling these successes across all subsectors and achieving national food security goals (Prime Minister's Office, 2020; FAO, 2022).

However, Brunei Darussalam's journey towards digital agriculture must go hand in hand with inclusive access strategies, including financial, physical, and technical access, as well as efforts to ease bureaucratic processes. Tackling these challenges holistically can unlock greater adoption amongst farmers, improve productivity, and align with national food security goals. Key to success will be government co-ordination, targeted incentives, and a focus on ease of use, affordability, and ongoing support.

There are many opportunities for the government to increase support and provide incentives to encourage the adoption and use of digital technologies to increase productivity and reduce costs. At the same time, the younger generation has become increasingly cognizant of food security and health. Consequently, there has been a surge in demand for traceable and high-quality food products amongst consumers. Furthermore, there are abundant opportunities and considerable potential for regional collaboration and technology transfer (ASEAN Secretariat, 2021).

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Chapter 4

Current and Future Application of Digitalisation in Agriculture and Food Systems for Enhancing Resilience and Improving Sustainability in Cambodia

Kong Thong and Ly Visoth

4.1 Introduction

Agriculture continues to play a crucial role in ensuring food security; enhancing economic opportunities for farmers and consumers, particularly the most vulnerable individuals residing in rural and urban areas; and fostering economic growth by balancing conservation and development for environmentally sustainable agriculture and Cambodia's economy. Agriculture remains important for producing food to meet people's needs. Recently, farmers have been facing a shortage of labour due to the migration of young people, particularly those aged 14–34, who seek better income opportunities in large cities and abroad. According to the Organisation for Economic Co-operation and Development (2017), migration from the agriculture sector reaches up to 80%. In this context, farmers need to use mechanisation and other tools in production to sustain supply and maintain their livelihoods, such as smart irrigation systems, drones for spraying pesticides and liquid fertiliser, and other technologies. The shortage of labour affects not only agricultural production but also the entire food value chain. To address the challenges caused by labour shortages, the government has encouraged farmers to use smart or digital agriculture in their production to sustain output. With support from the government, smart or digital agriculture has grown significantly for some agricultural commodities. For example, the Ministry of Agriculture, Forestry and Fisheries has introduced the Strategic Plan for Digitalisation 2024–2028 (MAFF, 2023) to support smart farming practices.

4.2 Method

Based on the diversity of agricultural crops grown across the country, the samples were selected by identifying specific farmers who were using smart or digital agriculture, as indicated by the Provincial Departments of Agriculture of Kampong Chhnang, Battambang, Banteay Meanchey, Kampong Tom, and Kandal. The interviewees were selected using the snowball sampling method. Data were collected from farmers and other stakeholders using structured questionnaires, individual face-to-face interviews, and online surveys, as well as by sending the questionnaire to specific respondents. Data collection took place from late February to early April 2025.

The informants were farmers who either utilised or had limited use of digital agriculture. Rice farmers who applied smart or digital agriculture were selected more frequently as respondents than other farmers, such as vegetable growers. This is because rice crops are more often abandoned in Cambodia than other agricultural commodities. The target respondents were smallholder farmers growing not only rice but also vegetables, as these farmers had neglected their smallholding areas. Most of the areas chosen for data collection were provinces surrounding the Great Tonle Sap Lake for rice cultivation and Kandal Province for vegetable production. Provinces near Phnom Penh were selected for animal husbandry, as the majority of livestock raising occurs close to the city.

4.3 Data Analysis and Interpretation

4.3.1 Profile of the Respondents

The research team collected relevant and reliable data from respondents for this study. A total of 119 respondents were interviewed, comprising 77 male respondents (65%) and 42 female respondents (35%). The proportion of male respondents was higher than that of female respondents, accounting for roughly two-thirds of the sample. The age of respondents engaged in the study were aged 20–71 years, with 78% above 30 years old. Most of the respondents interviewed in the study were farm owners.

The majority of respondents were farmers (86%), whilst 9% were technology providers, followed by distributors (3%) and wholesalers (1%). Amongst the 119 respondents, rice farmers accounted for about 59%, greenhouse vegetable growers for 21%, and farmers using traditional methods for about 16%. All respondents had different levels of experience in using smart or digital agricultural technology in their production. The study shows that 34% of respondents had used smart or digital agricultural technology in their business for less than 5 years, 24% had 5–10 years of experience, 14% had 11–20 years of experience, and 28% had more than 20 years of experience.

The educational attainment of the surveyed respondents indicates their understanding and adoption of smart and digital agricultural technology. About 21% of respondents had completed higher education, which correlates with the adoption of digital technology. Meanwhile, 37% of respondents have completed secondary school, and 41% had completed primary school. Based on the education and age of the respondents, it is believed that higher education makes people more receptive to new technology than those with lower educational attainment (Tabel 4.1).

Table 4.1. Details of the Respondents

Aspect or composition	Total	Share (%)
Category of respondent		
Farmer	102	86
Wholesaler	1	1
Processor	0	0
Distributor	4	3
Co-operative	0	0
Technology provider	11	9
Consumer	0	0
Other	1	1
Years of Experience		
<5 years	40	34
5–10 years	29	24
11–20 years	17	14
>20 years	33	28
Gender		
Male	77	65
Female	42	35
Age		
<30	26	22
31–40	33	28
41–50	28	24
51–60	25	21
>60	7	6
Education		
Primary	49	41
Secondary	44	37
Vocational	1	1
Higher (diploma, bachelor's, master's, or doctorate)	25	21

Source: Authors.

4.3.2 Current Status of Technology Applications

The study indicates that the main technology used by farmers was drones (60%) for spraying pesticides and fertilisers in rice production. Other technologies used by the farmers included Internet of Things (IoT) sensors (21%), automation (3%), precision agriculture (2%), farming advisory apps (1%), and robotics (1%). The findings provide evidence that the use of smart or digital agricultural technology by farmers reflects diverse applications and is increasing, as indicated by respondents' experience in using these technologies.

With regard to the distribution, marketing, and financing of agricultural produce, the study indicates that 25% of respondents used digital apps for financing and payments amongst suppliers and buyers, 8% used digital payment systems with banks, 2% used digital marketplaces, and 2% used sensor and IoT-based systems for sorting farm produce. Moreover, in terms of the digital traceability of farm commodities in domestic and international markets, the survey shows that 18% of respondents had applied inbuilt QR codes or barcodes containing product information, 2% had applied sensor and IoT-based systems for sorting farm produce, and 1% had applied blockchain technologies to identify product and logistics information.

Farmers currently apply smart or digital agricultural technologies to fulfil several needs. Respondents indicated that these technologies are used to increase agricultural production and productivity (38.65%), deal with labour shortages (54.62%), introduce appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding (32.77%), assure consumers of the origin and quality of products (21.84%), reduce production and operation costs (46.21%), increase food safety (36.13%), enhance the quality of farm production (30.25%), promote more environmentally friendly agriculture, including the reduction of greenhouse gas emissions (19.32%), and explore new marketing opportunities (35.29%), as shown in Table 4.2.

Table 4.2. Proportion of Respondents Intending to Implement Digital Solutions Within the Agriculture and Food Value Chain

No.	Reason	Share (%)
1	Increasing agricultural production and productivity	38.65
2	Reducing production/operation costs	46.21
3	Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding	32.77
4	Dealing with labour shortages	54.62
5	Enhancing the quality of farm production	30.25
6	Reducing post-harvest losses, and food loss and waste	7.56
7	Mitigating the impacts of climate change (floods, droughts, etc.)	4.20
8	Promoting more environmentally friendly agriculture, including the reduction of greenhouse gas emissions	19.32
9	Exploring new marketing opportunities	35.29
10	Increasing food safety	36.13
11	Assuring consumers of the origin and quality of products	21.84
12	Data management, including data collection, analysis, storage, transfer, and sharing	3.36
13	Applying for support, such as subsidies and insurance, in agriculture, e.g. through e-government platforms	3.36
14	Other	0

Source: Authors.

Table 4.3 shows that farmers face several challenges in using smart or digital agricultural technologies, such as the high cost of adopting new technologies (46%), limited digital literacy regarding available and potential digital technologies (20%), farmers' land size (11%), and a lack of extension workers and digital technology service providers with digital skills (10%). According to the data collected, as mentioned above, the challenge of using new technology remains one of the most significant amongst respondents.

Table 4.3. Proportion of Challenges Faced by Stakeholders

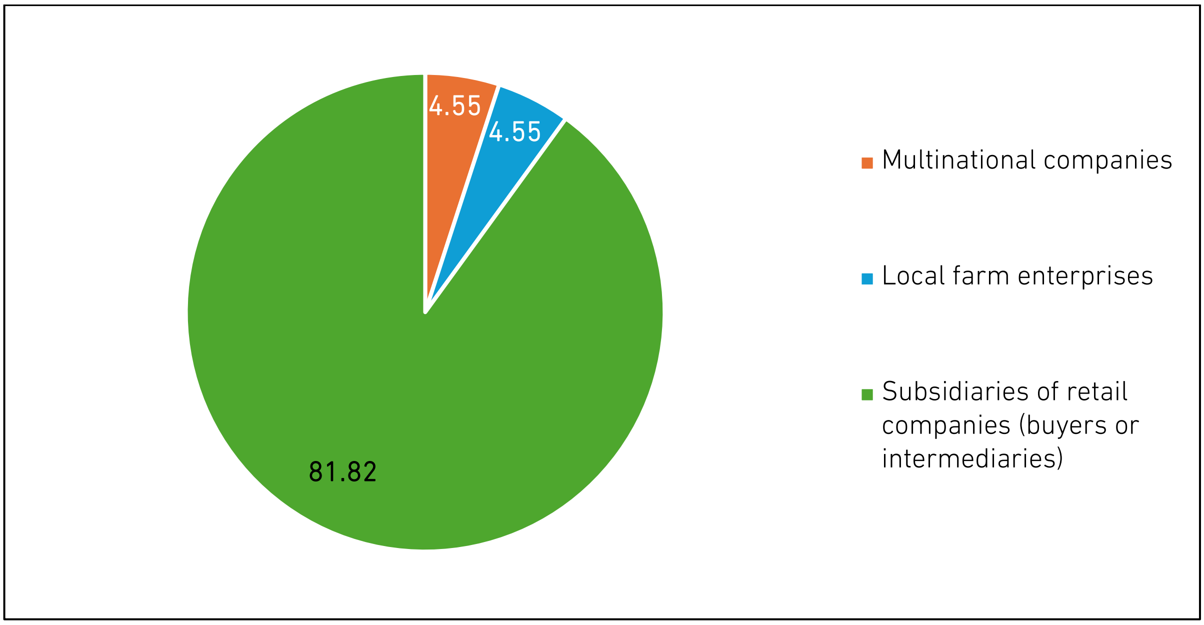
Challenge		Share (%)
Infrastructure		
1	Availability of an uninterrupted electricity supply	3
2	Access to broadband internet	3
3	Farmers' land size	11
4	Climate-induced natural disasters, including frequent floods, droughts, and landslides	3
5	Underdeveloped mechanisation (lack of equipment and tools)	4
Human resources		
1	Digital literacy regarding available and potential digital technologies	20
2	Lack of extension workers and digital technology service providers with digital skills	10
3	Lack of digital skills or training at the farm level	8
4	Lack of digital skills or training along the value chain	4
5	Conservative attitudes, such as resistance to change	3
Financial		
1	High cost of adopting new technologies	46
2	Lack of financial incentives for developing infrastructure and training programmes	6
3	Limited public support for the uptake of digital technology	3
4	Access to concessionary loans and credit	3
Institutional		
1	Limited policy instruments and framework conditions that support agriculture digitalisation	6
2	Lack of intergovernmental co-ordination and/or organisational structure	2
3	Inconsistent government strategies and frequent changes in farm policy	2
4	Lack of co-ordinated operations amongst public–private and local stakeholders	3
Digitalised data management and information transfer		
1	Digitalised data availability and the cost of digitalisation	3
2	Lack of facilities for data provided by the public or private sector, such as soil maps and market information	4
3	Cybersecurity threats	3
4	Software management in local languages for data integration and data sharing	1

Source: Authors.

4.3.3 Analysis of the Status of Private Sector Involvement

The government encourages private companies to develop new technologies that support farmers in adopting innovative practices to increase production. Through this programme, some private companies have developed smart irrigation systems to support farmers in specific agricultural commodities and locations in the country. The study found that 22 respondents (18%) had received some support from the private sector, as companies also receive support from the government to recreate technologies that help farmers. Most of the support (82%) came through company subsidies, compared with support from multinational companies (4.5%) and local companies (4.5%). The study indicates that, in addition to government support, some private companies have started to support farmers in certain aspects of technology, which was a positive sign for the future development of agricultural production, as shown in Figure 4.1.

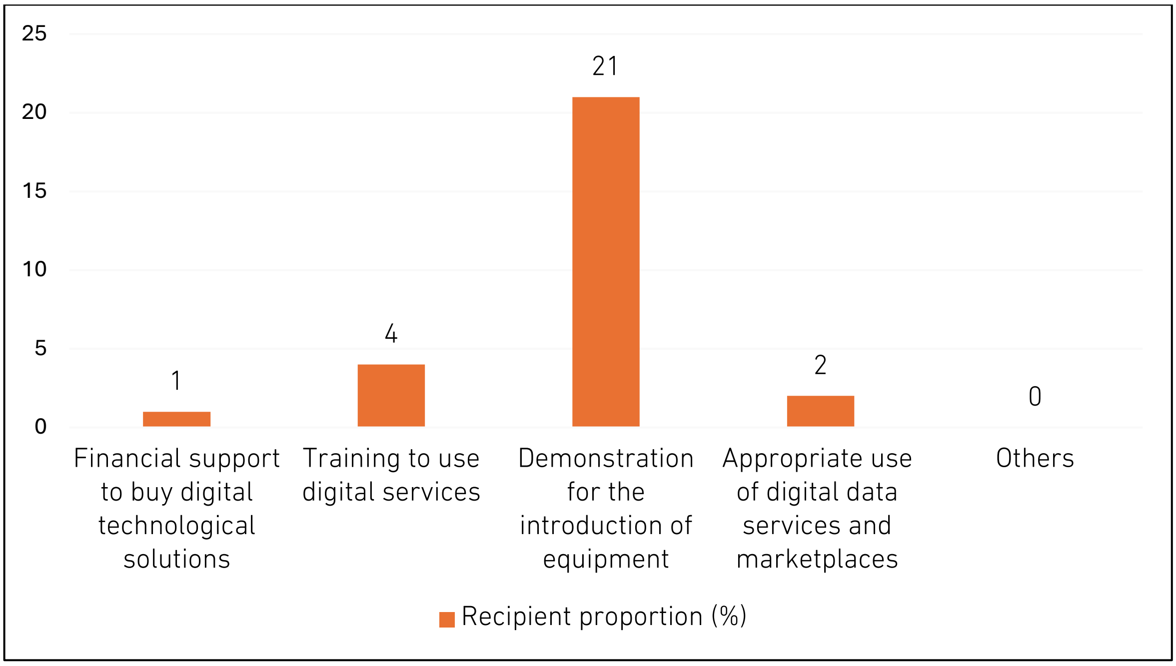
Figure 4.1. Type of Private Sector Involvement in Support Provision (%)



Source: Authors.

Twenty-two recipients received four types of support from the private sector. Companies supported stakeholders through equipment demonstrations, which accounted for 21% of all types of support. In addition, companies also conducted training on the use of devices, as shown in Figure 4.2.

Figure 4.2. Type of Support Provided by the Private Sector

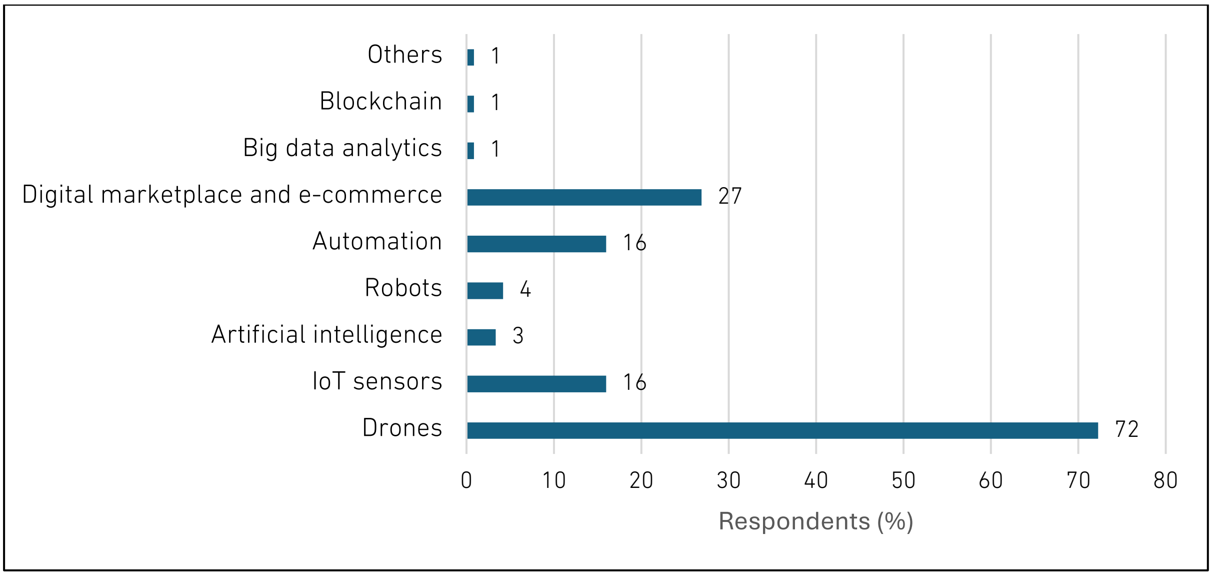


Source: Authors.

4.3.4 Expectations of Digital Technologies

Smart or digital agricultural technology has become crucial across the entire food value chain and food system. To explore the future need for digital agriculture in food value chains and food systems, respondents were asked about the technologies that could have an impact on their food value chains or food systems. The study showed that up to 86 respondents (72%) would need drone technology to reduce production costs. Most drones used by farmers are related to spraying pesticides and, sometimes, fertilisers. Farmers reported difficulties hiring people to spray pesticides, as well as the high cost of spraying and related labour costs. Other technologies were also identified as needed, such as IoT sensors (16%), automation (16%), digital marketplaces and e-commerce (27%), robots (4%), artificial intelligence (AI) (3%), blockchain (1%), big data analytics (1%), and others (1%), as shown in Figure 4.3. These results indicate that digital technology is pivotal for farmers, producer, wholesalers, technology providers, and communities in improving the economics of production in the future.

Figure 4.3. Future Predictions of Required Technology in ASEAN



Source: Authors.

4.4 Overview of Policies, Government Initiatives, and Programmes for Promoting the Utilisation of Digital Technologies in Agriculture and Food Systems

4.4.1 Policies and Initiatives Provided by the Government

The Fourth Industrial Revolution in Cambodia has had a profound effect on the economy and society through the use of AI technology, data analytics, drones, automation, and IoT. These digital technologies have led to rapid and unprecedented changes in education, agriculture, health, employment, business, public administration, and other areas. Moreover, necessary strategies designed by the Government of Cambodia for future implementation include the ongoing modernisation and expansion of digital infrastructure connectivity, the promotion of a support ecosystem for research and innovation, and the capacity building of civil servants through digital technology.

However, this Industrial Revolution also brings several challenges, including crimes related to digital security, the protection of personal data, data security, transnational crimes, and the online sexual exploitation and abuse of children and women. In this regard, the government will implement necessary policies in accordance with the 'Cambodia Digital Economy and Society Policy Framework 2021–2035' to ensure a digital ecosystem that is strong and resilient to various crises and responds in a timely manner to the development of digital technology. In compliance with this policy framework, the government has set out the 'Cambodia Digital Government Policy 2022–2035', focusing on the vision of 'establishing digital government to improve citizens' quality of life and build their trust through better public service provision'. This includes creating national co-ordination and implementation mechanisms through the establishment of the Digital Government Committee and units in charge of digital transformation in ministries, institutions, and subnational administrations; preparing priority national budgets; and recruiting technical officers.

The Royal Government of Cambodia has developed the 'Digital Economy and Society Policy Framework of Cambodia 2021–2035' (Supreme National Economic Council, 2021), with the vision of 'building a vibrant digital economy and society to promote new economic growth and promote social welfare based on normalcy in a new direction'. This policy framework focuses on two foundations: infrastructure development to support the digital revolution, and building trust and confidence in digital systems. At the same time, the 'Cambodia Digital Government Policy 2022–2035' (Ministry of Post and Telecommunications, 2022) has been developed and implemented based on the design of digital connectivity infrastructure, the provision of public services to the people, and the development of digital human resources. This digital government policy has a common vision for a vibrant digital economy and society, emphasising the importance of digital transformation in all sectors, including agriculture, which is an important part of contributing to economic development and an important source of livelihood. In addition, it has been developing and implementing policies and strategies related to the agricultural sector to increase productivity, food security, economic efficiency, and social welfare by setting out four pillars: 'have to eat, have to use, have to have, and have forever'.

Following the trend of modernisation, the Ministry of Agriculture, Forestry and Fisheries has a vision to digitalise agriculture through the integration of digital technologies in agricultural practices, thereby accelerating development, improving efficiency and service delivery, strengthening public services, increasing confidence, and improving the lives of farming families. In this regard, the Ministry of Agriculture, Forestry and Fisheries has prepared the 'Strategic Plan for Digitalisation of the Ministry of Agriculture, Forestry and Fisheries 2024–2028' (MAFF, 2023) to support the implementation of the government's policy on the digital revolution. This can help accelerate operations in agriculture, increase economic efficiency, and improve the provision of public services by increasing the use of digital technology and identifying four priority strategies: (1) designing and strengthening digital infrastructure and nurseries; (2) enhancing digital human resource capacity; (3) promoting the provision of digital services to the public; and (4) improving database management.

4.4.2 Effectiveness of Government Initiatives, Programmes, and Support

Agricultural technology is developed rapidly, especially smart or digital agricultural technology to improve crop production. To assess the level of support for smart or digital agricultural technology amongst the surveyed respondents, the respondents were asked whether they had received financial, technical, and in-kind support from the government. Financial support, such as subsidies, access to credit, and tax incentives, was received by 5.8% of respondents to support the application of digital agricultural technology in their production. Amongst them, around 57% reported receiving sufficient support from the government. Conversely, the remaining 43% perceived that the support provided was insufficient. The survey implies that the government provides some financial support, but it remains limited.

The study also noted that 28 respondents (23.5%) had received training on technical support from the government, which was much higher than the share receiving financial support. However, only 14 of them (50%) said that the training was sufficient. The study found that only one respondent received in-kind support from the government, and this was considered insufficient. The study indicates that respondents received technical training support more frequently than other forms of support, such as financial and in-kind support, as shown in Table 4.4.

Table 4.4. Government Support to Value Chain Stakeholders and Its Sufficiency

Support type	Proportion of recipients (%)	Support rating: sufficient (%)
Financial support	5.88	57.14
Technical support	23.53	50.00
In-kind support	0.84	0.00

Source: Authors.

The Cambodia Data Exchange platform, CamDX, which is under the direction and management of the Ministry of Economy and Finance and the Ministry of Posts and Telecommunications, is a platform for data sharing within the government, following its announcement by the Royal Government of Cambodia. All sectors in the ministries must adapt to the platform to share data across ministries. At the same time, Cambodia Data Exchange platform will strengthen the quality, security, and privacy of data and promote data sharing. To strengthen data management and adapt to the Cambodian Data Exchange platform, the Ministry of Agriculture, Forestry and Fisheries will:

a. Prepare a list of data and create metadata to consolidate data from the Ministry of Agriculture, Forestry and Fisheries for overall management.
b. Collect data, share data, and use databases in the system, for example through the Inclusive Agricultural Statistics System.
c. Strengthen data collection through commune agriculture officials by collecting data at the grassroots level using digital systems.
d. Prepare a list of databases to be shared across ministries through the Cambodia Data Exchange platform.

4.5 Recommendations

To continue supporting the growth of digital agriculture technology, several points should be considered:

a. Education, research and development, and training on digital technology should be consistently promoted to respond effectively to the rapid changes in digital agriculture technology.
b. Reskilling and upskilling schemes should be in place to ensure sustainable and inclusive development and guarantee that no one is left behind.
c. Investments are needed in digital transformation in the agriculture sector, including computers, robotic systems, remote sensing, sensors, cloud-based decision models, drones, and IoT.
d. Digital Transformation Technology Innovation should be the driving force for present and future development in the agricultural sector and other sectors.
e. The government should invest in research and development in agriculture, including the crop, livestock, and fisheries sectors, to increase sustainable productivity, competitiveness, adaptation, and resilience.
f. Public–private partnerships should be supported to increase access to inclusive finance schemes and programmes for promoting mechanisation and technology adoption in agricultural digital transformation.
g. Agricultural digital transformation research and innovation should be promoted.
h. As the government has supported the implementation of digital transformation technology, and the Ministry of Agriculture, Forestry, and Fisheries has established digitalisation strategies for agriculture, a committee or specific authorities should be created to conduct monitoring and evaluation of all activities set out for implementation under these strategies.

4.6 Conclusion

The Royal Government of Cambodia, especially the Ministry of Agriculture, Forestry, and Fisheries, has developed the 'Strategic Plan for Digitalisation of the Ministry of Agriculture, Forestry and Fisheries 2024–2028' to support the 'Digital Economy and Society Policy Framework of Cambodia 2021–2035' and the 'Digital Government of Cambodia Policy 2022–2035'. Through this policy support, smart and digital agriculture technology has developed rapidly in Cambodia, not only in crop production but also across the entire food value chain and food system.

Currently, Cambodia has mostly adopted drone technology to support production, compared with other technologies such as digital payment systems with banks, sensor and IoT-based systems for sorting of farm produce, blockchain technologies to identify product and logistics information, and inbuilt QR codes or barcodes containing product information to enhance the production.

However, farmers still face several challenges, such as high cost of tools, limited digital literacy regarding available and potential digital technologies, a lack of extension workers and digital technology service providers with digital skills, a lack of digital skills or training at the farm level, a lack of financial incentives for developing infrastructure and training programmes, limited policy instruments and framework conditions that support agriculture digitalisation, limited public support for the uptake of digital technology, and issues related to digitalised data availability and the cost of digitalisation.

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Chapter 5

Harnessing Digitalisation for Resilient and Sustainable Agriculture in Indonesia

Subejo, Alia Bihrajihant Raya, Ishadiyanto Salim, and Rani Nur Rochim

5.1 Background

In recent years, digital technologies have begun to transform Indonesia's agricultural sector, providing new tools to enhance productivity, efficiency, and sustainability throughout the agricultural value chain. From crop monitoring and precision farming to digital marketplaces and supply chain logistics, these innovations are gradually being integrated into farming practices in production and distribution (Anshari et al., 2019; Rauf et al., 2023). The increasing pressure from climate change, labour shortages, and market volatility has further accelerated the need for innovative solutions that support more resilient and adaptive farming systems.

Whilst the overall adoption rate of digital technologies remains uneven across regions, commodities, and farm scales, several agricultural subsectors in Indonesia have demonstrated early and promising engagement. These early adopters reflect the growing relevance of digitalisation in agriculture and serve as reference points for potential efforts for scaling-up. Horticultural farms, for instance, have rapidly embraced automated irrigation systems and sensor-based monitoring, allowing them to respond more efficiently to water needs and changing environmental conditions. Similarly, some food crop producers, especially rice farmers, have begun using drones for aerial surveillance and precision input applications, contributing to more effective farm management.

Nevertheless, the transformative potential of digital agriculture in Indonesia is still far from being fully realised. Many farmers, particularly smallholders, who comprise most of the agricultural labour force, face significant barriers to accessing, adopting, and utilising digital tools. These include limited digital literacy, insufficient internet connectivity in rural areas, and the high cost of advanced agricultural technologies. Without adequate support, the risk of deepening the digital divide within the farming community looms large.

As such, understanding both the patterns of digital adoption and the context-specific challenges faced by different types of farmers is essential. This preliminary assessment study seeks to capture those dynamics, providing a baseline view of how digitalisation has unfolded in Indonesia's agriculture and food system landscape. The findings are expected to inform more inclusive strategies to foster resilience and sustainability through digital innovation in the sector.

5.1.1 Early Adoption in Horticulture and Food Crops

Horticulture has been at the forefront of digital technology adoption in Indonesia. Farmers cultivating high-value crops such as vegetables and fruits have increasingly implemented automated irrigation systems, leveraging Internet of Things (IoT) devices to monitor soil moisture and optimise water usage. These technologies enable real-time adjustments, increasing resource utilisation and improving crop yields.

The use of drones has gained traction in food crops, particularly rice cultivation. Drones equipped with multispectral cameras and sensors are employed for aerial monitoring, pest control, and even precision spraying of fertilisers and pesticides. This technology allows timely interventions, reducing labour costs and minimising environmental impacts.

5.1.2 Predominant Digital Technologies in Use

In Indonesia, digital technologies are increasingly being adopted in agriculture, particularly in horticulture and food crop farming. Weather applications are one of the most common tools amongst farmers, helping them monitor localised weather conditions and plan planting and harvesting accordingly. These applications provide critical data on rainfall, temperature, and humidity, which can significantly reduce risks associated with climate variability. Digital advisory platforms have also become widely used for knowledge sharing and guidance. Farmers access information through platforms like YouTube, WhatsApp, Facebook, and various agricultural websites to find tutorials and farming tips and connect with agricultural experts and fellow farmers (Abdulai, 2024; Ahmadi et al., 2021).

E-commerce platforms have also transformed the agricultural sector, allowing farmers to sell their products directly to consumers and bypass traditional market intermediaries (Anshari et al., 2019). Several local government-supported platforms have been launched to connect farmers with buyers, helping to improve market access, particularly for smallholder farmers. Additionally, social media platforms like Facebook have become essential for farmers to engage in community-based selling and sharing of agricultural products within local groups or marketplaces. These digital tools empower farmers to reach broader markets and gain more control over pricing and sales channels (Hariadi et al., 2023).

Moreover, drone technology is gaining popularity for precision agriculture, especially in large-scale rice farming. Drones equipped with sensors are used for aerial surveillance, pest control, and even precision spraying of fertilisers and pesticides, significantly reducing labour costs and environmental impact. Despite these advances, the adoption of digital technologies in Indonesia's agriculture sector remains limited due to challenges such as inadequate infrastructure, low digital literacy, and high costs. Overcoming these barriers will enable more widespread and sustainable digitalisation in agriculture.

5.1.3 Trends and Local Context of Digitalisation

Despite these advancements, the overall adoption of digital technologies in Indonesian agriculture remains limited. Challenges such as inadequate infrastructure, limited digital literacy amongst farmers, and high initial investment costs hinder widespread implementation. Government initiatives, including training programmes and infrastructure development, aim to address these barriers, but progress is gradual. Another challenge is the interrelated barriers, socio-economic factors, significant investment costs, and inadequate training for farmers that constrain the integration of digital solutions into agricultural practices, particularly for small and medium-scale farmers (Agussabti et al., 2022). The need for financial incentives and tailored advisory services to encourage adoption suggests that governmental policies offering subsidies or tax breaks could alleviate the financial burden associated with digital technology investments (MacPherson et al., 2022).

The disparity in digital adoption underscores the urgent need for targeted policies and inclusive support mechanisms to ensure that the benefits of agricultural digitalisation are accessible to all farmers, regardless of their scale or location. Whilst larger, commercially oriented farms are more likely to adopt advanced tools, smallholder farmers, who make up the majority of Indonesia's agricultural sector, often face significant barriers such as limited infrastructure, low digital literacy, and a lack of financial resources. These constraints hinder adoption and risk deepening existing inequalities in the rural economy.

5.2 Method

5.2.1 Data Collection Methods

This study employed a quantitative methods approach to gather comprehensive insights into adopting digital technologies amongst farmers. First, a structured questionnaire was administered in person to capture quantitative data on technology use, frequency, and perceived benefits and challenges. Second, individual interviews were conducted offline through face-to-face meetings with selected farmers to explore in-depth the benefits and challenges of digitalisation in agriculture and the food system.

5.2.2 Key Informants

Key informants were defined as users of digital technologies in agriculture and the food system, ranging from those who rely on basic advisory applications to those employing advanced tools such as drones and soil sensors. These informants provided expert perspectives on technology performance, barriers to implementation, and the support needed for broader adoption.

5.2.3 Targeted Agricultural Actors and Study Areas

The target population comprised farmers actively using digital tools, spanning simple advisory apps to sophisticated drone and sensor systems, in the Special Region of

Yogyakarta (SRY). A total of 100 agricultural actors were purposively sampled across four regencies (Kulon Progo, Gunungkidul, Sleman, and Bantul) and one city (Yogyakarta City).

The study surveyed 100 agricultural actors actively using digital technologies, representing diverse commodities: 36 were rice growers, 35 cultivated traditional fruits and vegetables, and 8 managed greenhouse-based fruits and vegetables. Additionally, 2 agricultural actors were involved in livestock and poultry farming, 1 in aquaculture, and the remaining 18 represented various other agricultural commodities.

Agricultural actors were selected to reflect the region's diverse topography, including upland areas in Kulon Progo and Gunungkidul, lowland plains in Yogyakarta City, Sleman, and Bantul, and coastal zones near Kulon Progo, thereby capturing how geographical and environmental factors shape digital technology use. These areas were chosen because they represent the region's full spectrum of agricultural conditions and host farmers at varying levels of digital maturity, making them ideal for understanding both early adoption patterns and advanced technology integration.

5.3 Data Analysis and Interpretation

5.3.1 Profile of Agricultural Actors

The agricultural actor profile data provide a comprehensive overview of the participants involved in the survey, highlighting various demographic and professional attributes. Most agricultural actors were farmers, accounting for 87% of the total, followed by distributors (5%), processors (3%), technology providers (3%), wholesalers (1%), and others (1%). This distribution indicates a strong representation of primary agricultural producers, which is crucial for understanding the adoption and impact of agricultural technologies.

Table 5.1. Average Profile of Agricultural Actors

	Category of agricultural actors					
	Farmers (87%)	Wholesalers (1%)	Processors (3%)	Distributors (5%)	Technology providers (3%)	Others (1%)
Land size (hectares)	0.34	0.02	0.12	0.07	0.13	0.08
Age (years)	43	26	38	39	34	57
Commodities	Rice	Others	Others	Others	Others	Fruits and/or vegetables
Years of experience	5–10 years	<5 years	5–10 years	5–10 years	5–10 years	5–10 years
Education	Secondary	Higher	Secondary–higher	Higher	Higher	Secondary
Gender	Male	Male	Female	Male	Male	Male

Source: Authors.

The average land size managed by the agricultural actors varies. Farmers have an average land size of 0.34 hectares, whilst other categories, such as wholesalers, processors, distributors, and technology providers, manage smaller average land sizes ranging from 0.02 to 0.13 hectares. This variation in managed land size reflects the diverse scale of farming operations amongst different types of agricultural actors.

The age distribution of the agricultural actors ranges from 26 to 57 years, with farmers having an average age of 43 years. This indicates a mix of younger and older individuals engaged in farming activities, which can influence the adoption of new technologies based on generational preferences and experiences.

Regarding cultivated commodities, rice is the primary crop grown by farmers, whilst other agricultural actors produce various other commodities, including fruits and vegetables. This diversity in crop production highlights the varied agricultural practices and needs amongst agricultural actors.

The years of experience amongst agricultural actors range from less than 5 years to 10 years, with the majority having 5–10 years of experience in their respective fields. This level of expertise suggests that agricultural actors have a substantial understanding of agricultural practices and may be more receptive to adopting new technologies.

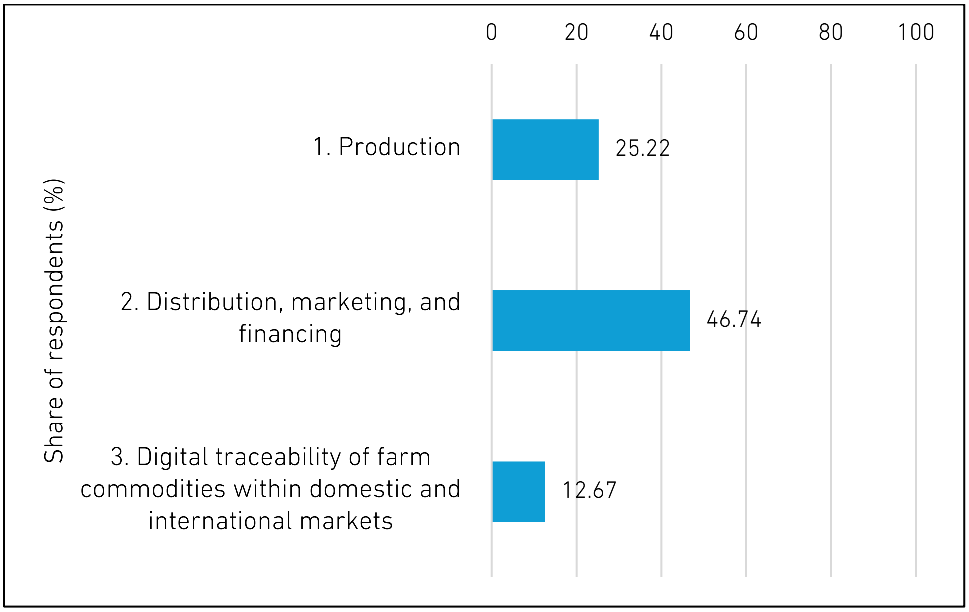
The gender distribution predominantly features male agricultural actors, except amongst agricultural product processors, with secondary and higher education levels being predominant amongst respondents. This educational background is essential for assessing the capacity of agricultural actors to understand and implement advanced agricultural technologies.

5.3.2 Analysis of Reality

5.3.2.1 Digital Technologies and Tools Used in Farming Activities and/or Activities Along the Food Value Chain

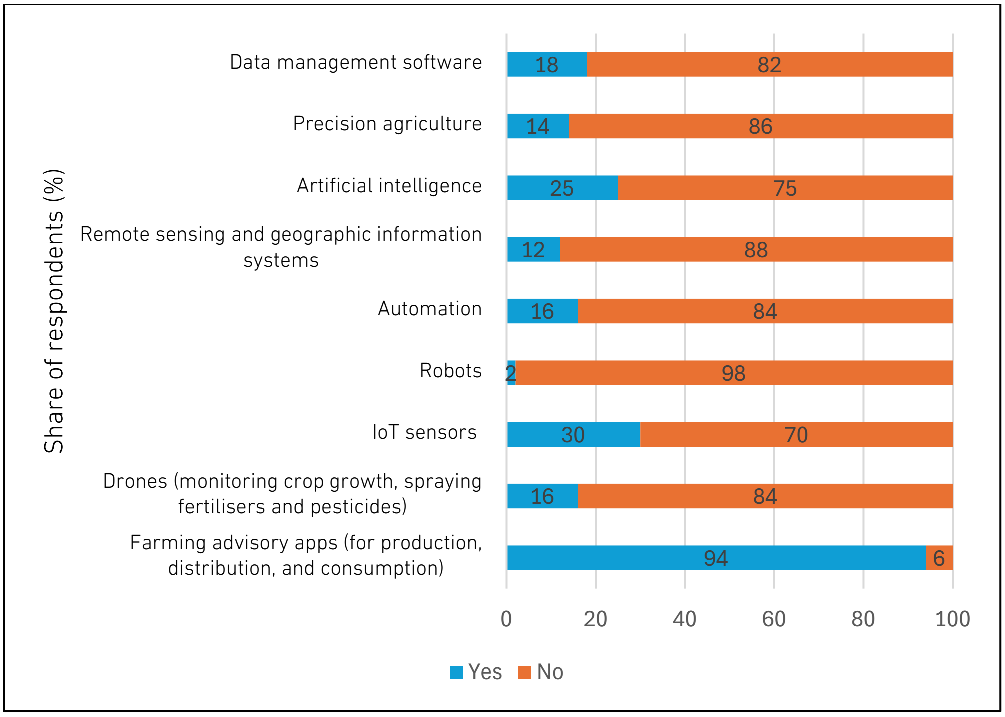
This analysis is based on survey data collected from farmers in the SRY. The utilisation of technology in this study is categorised into three segments: (a) production; (b) distribution, marketing, and financing; and (c) digital traceability of farm commodities within domestic and international markets. Amongst these categories, distribution, marketing, and finance exhibit the highest usage rate, at 46.74%, followed by production, at 25.22%, and digital traceability, at 12.67%. Based on the survey, several points can be highlighted regarding the usage of different types of technology, specifically the most widely used and the least used, or not yet used, technologies within each segment by farmers in SRY.

Figure 5.1. Comparison of Types of Activities



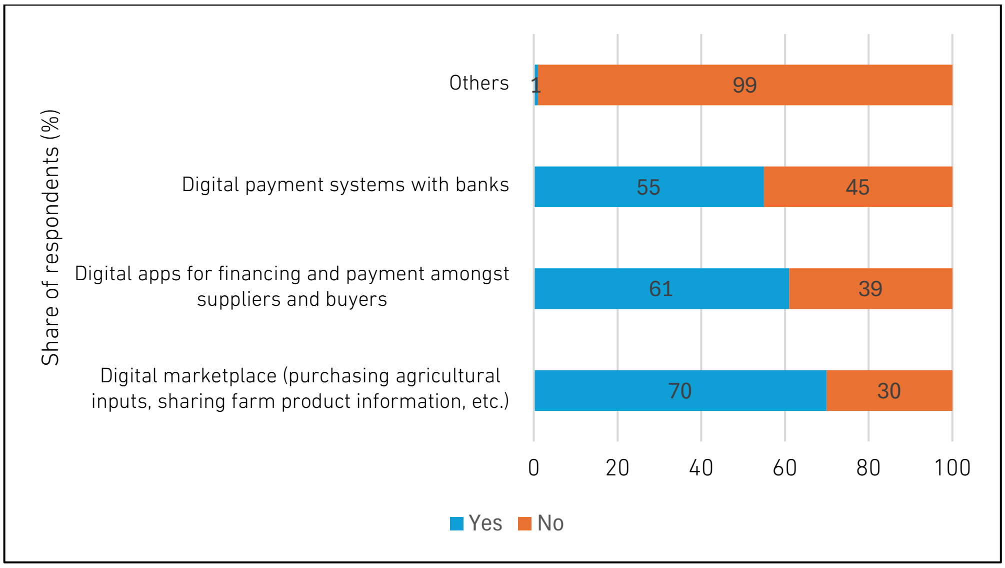
Source: Authors.

Figure 5.2. Use of Production Technologies



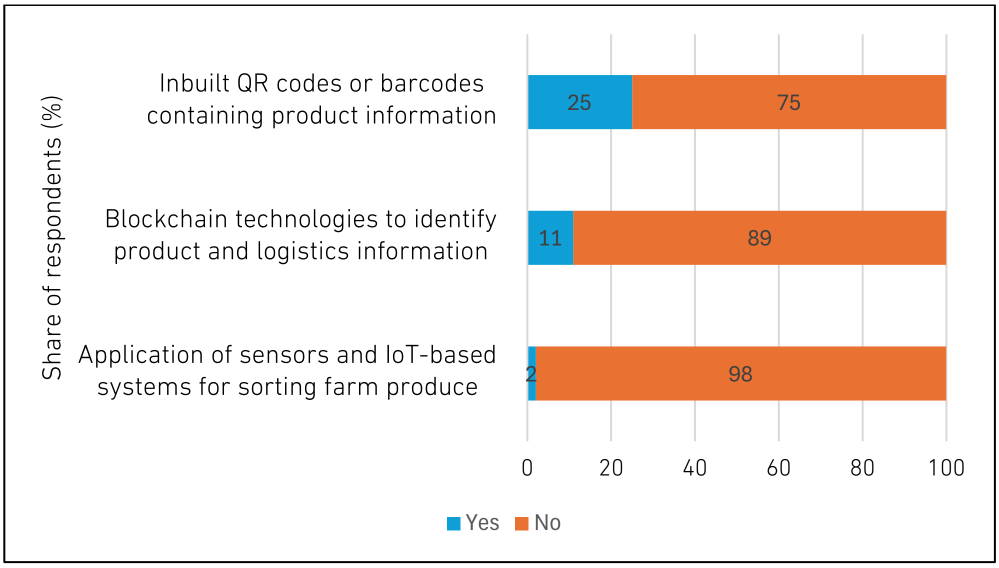
Source: Authors.

Figure 5.3. Use of Distribution, Marketing, and Financing Technologies



Source: Authors.

Figure 5.4. Use of Digital Traceability Technologies



Source: Authors.

5.3.2.1.1 Production

Agricultural production is enhanced through various technologies, including farming advisory apps, drones, IoT sensors, and robots, supported by geographic information systems (GIS) and artificial intelligence (AI) for optimised inputs and data analysis. Farming advisory apps have the highest adoption rate, with 94% of agricultural actors using them across production stages, highlighting their critical role in disseminating agronomic knowledge. The Desa Apps application, launched by the Faculty of Agriculture at Universitas Gadjah Mada, is widely used in Indonesia and provides a trusted platform for quick and accurate information. However, the use of robotics in agricultural production remains low due to high initial costs, the need for technical knowledge, and a preference for simpler technologies with immediate impacts.

5.3.2.1.2 Distribution, Marketing, and Financing

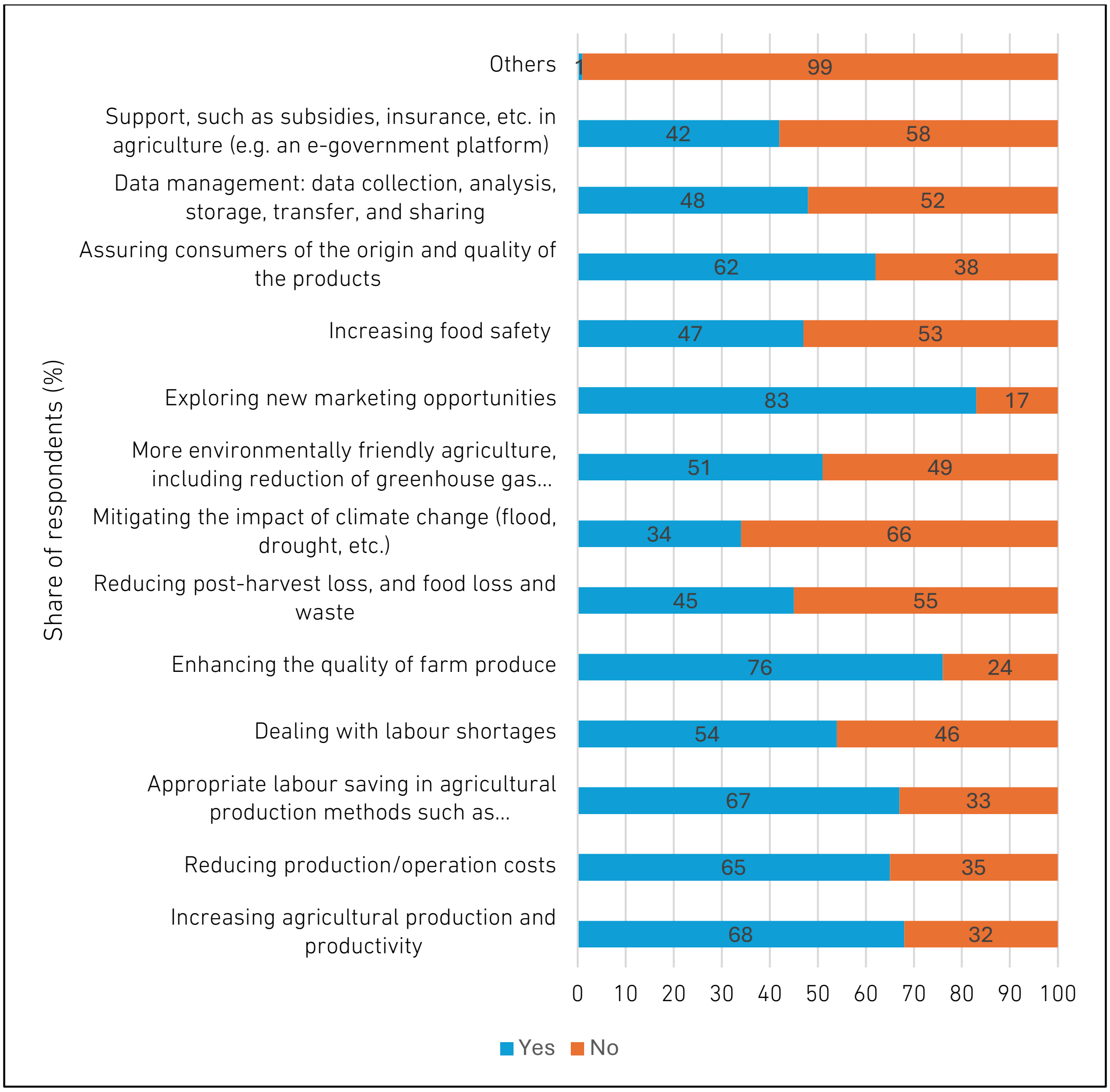
Farmers' use of technology in distribution, marketing, and financing shows significant adoption, especially in digital marketplaces, which account for 46.74% of usage. These platforms improve market access and provide competitive pricing, with Facebook Marketplace being popular due to its ease of use and direct customer interaction. Whilst some customers are new to digital payments, many farmers use mobile banking and QRIS, the Quick Response Code Indonesian Standard, for transactions. Farmers find QRIS particularly convenient and secure, as it reduces the risks associated with cash handling in traditional markets.

5.3.2.1.3 Digital Traceability

Digital traceability of farm commodities within domestic and international markets encompasses technologies used to track and authenticate agricultural products throughout the supply chain. According to Figure 5.1, this category has a low adoption rate of only 12.67%. The low adoption rate of digital traceability technologies may be due to several factors, such as a lack of awareness, perceived complexity, or unproven direct benefits at the farm level. However, adopting these technologies indicates a growing trend towards more transparent supply chains and better product authentication.

5.3.2.2 Needs Areas in the Agriculture and Food Value Chain Where Farmers Want to Apply Digital Solutions

Figure 5.5. Needs Areas in the Agriculture and Food Value Chain



Source: Authors.

Figure 5.5. illustrates the needs that farmers aim to address using technology. The utilisation of technology based on its intended purpose can be categorised into six areas: production objectives, labour efficiency, quality improvement and post-production, environmental objectives, market and consumer objectives, and data and support.

Farmers increasingly seek digital solutions to address key agriculture and food value chain needs. A primary focus is boosting agricultural production and productivity whilst cutting operational costs. The data show that 68% of farmers prioritise increasing production, and 65% aim to reduce costs through technologies like farming advisory apps and drones for precise agronomic recommendations and crop monitoring.

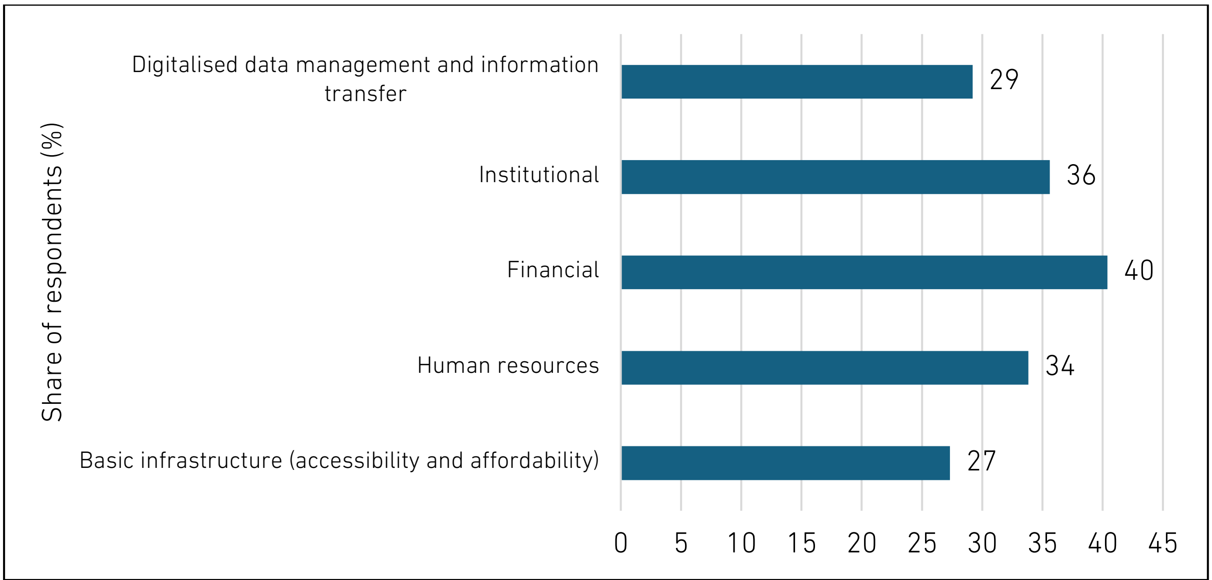
Labour efficiency is another critical area, with 67% of farmers seeking labour-saving solutions like improved irrigation, fertilisation, and feeding methods to combat labour shortages, which are a challenge faced by 54% of respondents. Enhancing the quality of farm produce and minimising post-harvest losses are also significant concerns, with 76% prioritising quality improvement and 45% focusing on reducing losses.

Environmental impact mitigation is gaining importance, as 34% of farmers consider it a key need, and 51% focus on environmentally friendly practices to combat climate change. AI and precision agriculture are seen as tools to reduce the negative environmental effects of farming. Furthermore, farmers are keen to explore new marketing avenues, increase food safety, and ensure product quality, with 83% prioritising market opportunities.

Meanwhile, 48% of farmers consider data management necessary, including data collection, analysis, storage, and sharing. Overall, technology in agriculture is being used to increase production, improve labour efficiency, enhance product quality, reduce environmental impacts, expand market opportunities, and improve data handling. As a result, farmers focus on productivity, labour savings, product quality, sustainability, and market access.

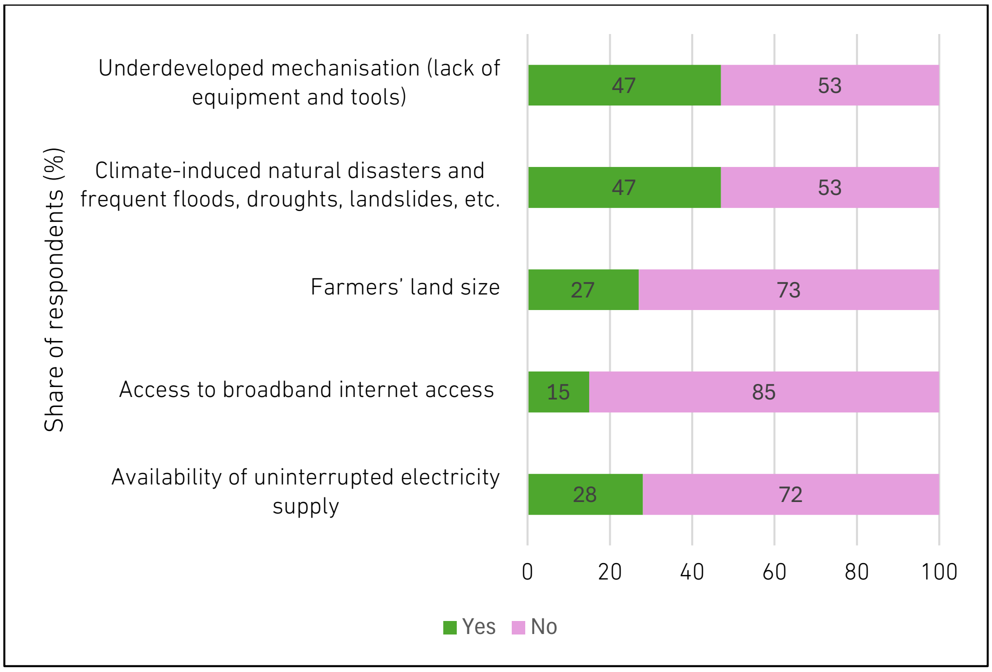
5.3.2.3 Challenges, Constraints, and Obstacles to Using Digital Technologies and Introducing Digital Solutions

Figure 5.6. Challenges, Constraints, and Obstacles to Using Digital Technologies and Introducing Digital Tools



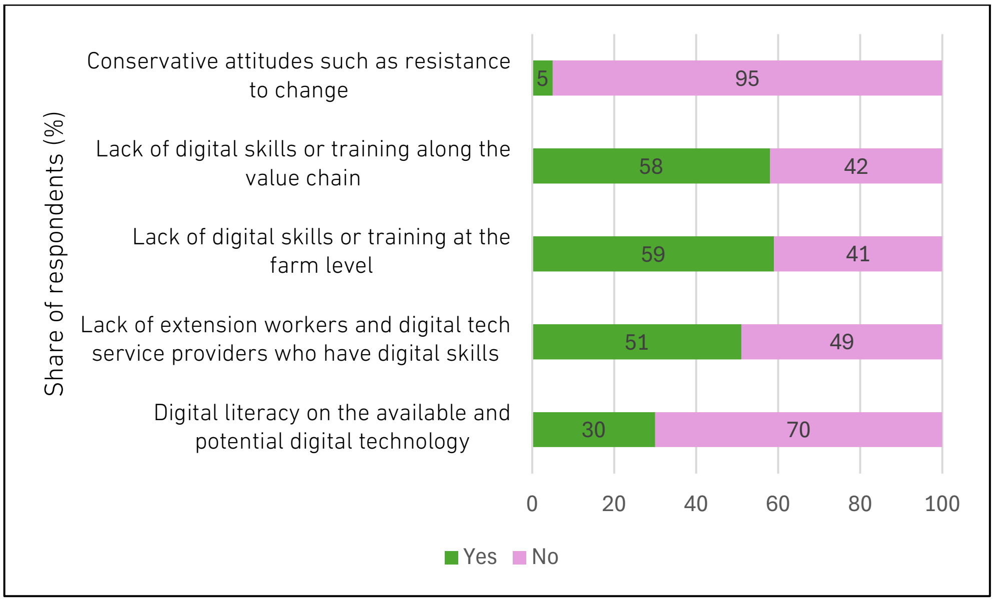
Source: Authors.

Figure 5.7. Lack of Basic Infrastructure



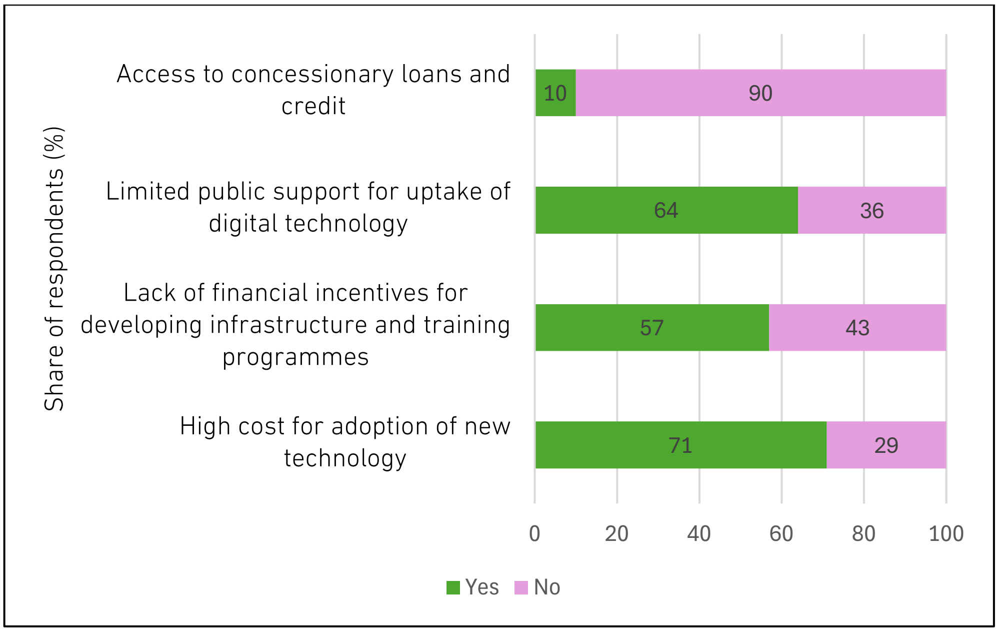
Source: Authors.

Figure 5.8. Human Resource Challenges



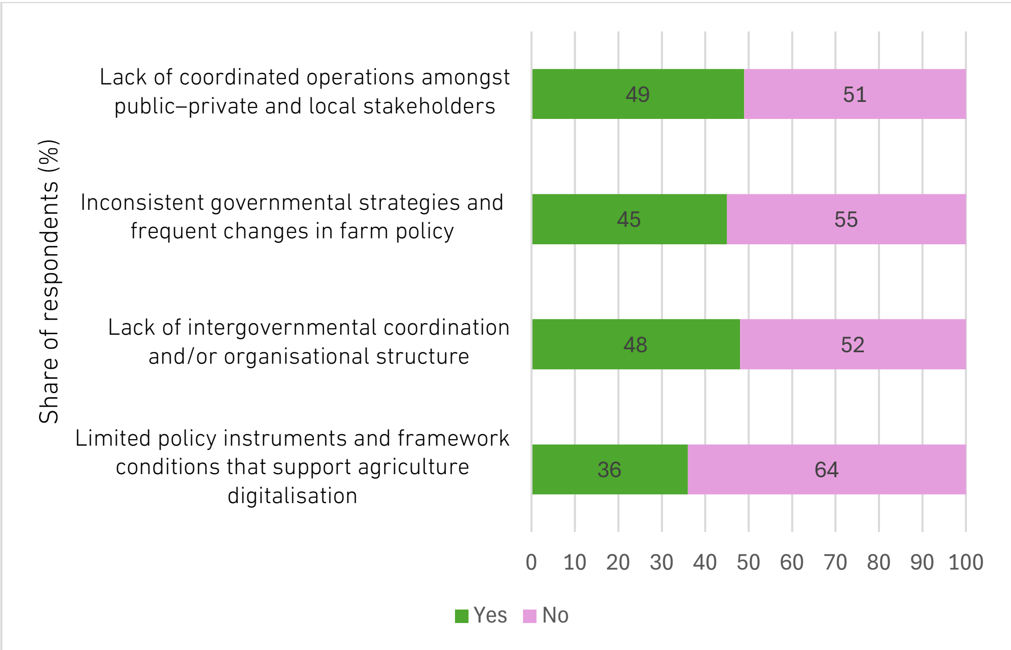
Source: Authors.

Figure 5.9. Financial Challenges



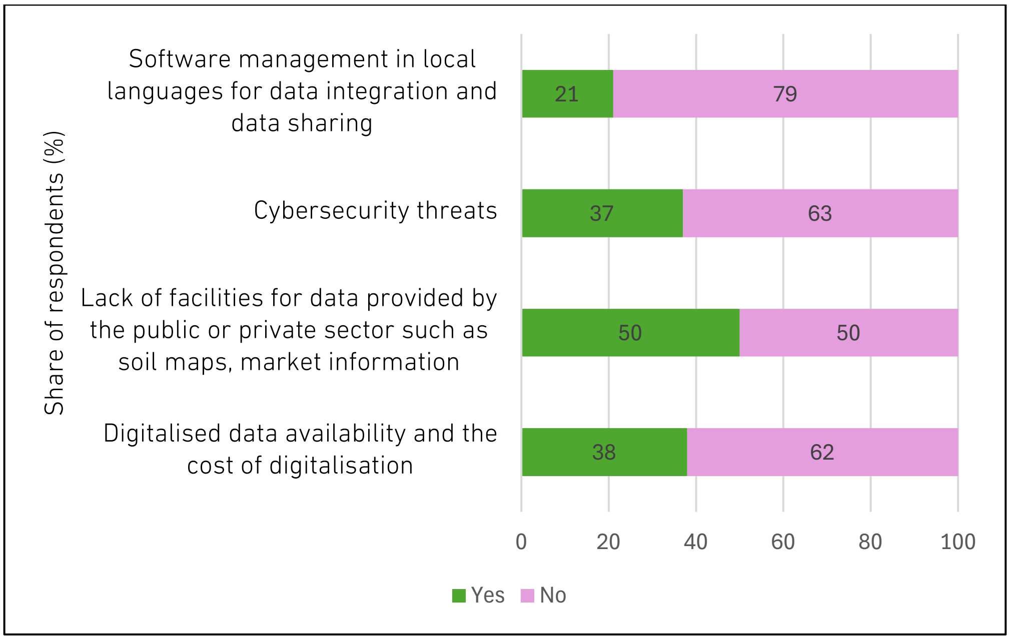
Source: Authors.

Figure 5.10. Institutional Challenges



Source: Authors.

Figure 5.11. Digitalised Data Management and Data Information Transfer Challenges



Source: Authors.

Five key points challenge the use of technologies in the SRY. In summary, the discussion based on Figure 5.6 reveals that farmers in the SRY are generally open to adopting new technologies. The primary barriers to adoption are related to the cost and accessibility of these technologies rather than resistance to innovation. Additionally, security concerns are not yet considered significant, indicating that the focus should be on addressing financial and infrastructure challenges to facilitate the adoption of digital technologies in agriculture.

5.3.2.3.1 Lack of Basic Infrastructure

The first point in Figure 5.6 addresses the lack of basic infrastructure, including accessibility and affordability. The availability of an uninterrupted electricity supply and access to broadband internet are critical components that are currently insufficient, with only 28% and 15% of farmers, respectively, indicating that they have access to these resources. Additionally, factors such as farmers' land size and climate-induced natural disasters further exacerbate the challenges faced by farmers.

5.3.2.3.2 Human Resource Challenges

The second point focuses on human resources, particularly digital literacy and the availability of extension workers and digital technology service providers with digital skills. Whilst 30% of farmers have some level of digital literacy, there is a significant gap in training and skills development at the farm level and along the value chain. Interestingly, conservative attitudes, such as resistance to change, are not prevalent, with only 5% of farmers indicating such resistance. This suggests that farmers are willing to embrace new technologies if provided with adequate training and support, further emphasising that the primary issue lies in the cost and availability of these resources.

5.3.2.3.3 Financial Challenges

The third point highlights financial constraints, including the high cost of adopting new technology and the lack of financial incentives for developing infrastructure and training programmes. A significant 71% of farmers identified the high cost of new technology as a significant barrier. Additionally, limited public support and access to concessionary loans and credit further hinder the adoption of digital technologies. Despite these financial challenges, farmers are not resistant to innovation; rather, they require more affordable solutions and financial support to facilitate the adoption of new technologies.

5.3.2.3.4 Institutional Challenges

The fourth point addresses institutional challenges, including limited policy instruments and framework conditions that support agricultural digitalisation. A total of 36% of farmers indicated that limited policy instruments and framework conditions support agricultural digitalisation. Additionally, 48% of farmers pointed out the lack of intergovernmental co-ordination and/or organisational structure, which hinders the effective implementation of digital technologies in agriculture. Inconsistent governmental strategies and frequent changes in farm policy were also highlighted by 45% of farmers as a significant barrier. Furthermore, 49% of farmers mentioned the lack of co-ordinated operations amongst public–private and local stakeholders as a challenge.

5.3.2.3.5 Digitalised Data Management and Information Transfer Challenges

The fifth point focuses on digitalised data management and information transfer, including the availability and cost of digitalisation. A total of 38% of farmers indicated that the availability and cost of digitalised data are significant barriers. Additionally, 50% of farmers pointed out the lack of facilities for data provided by the public or private sector, such as soil maps and market information. Cybersecurity threats were mentioned by 37% of farmers, indicating that whilst security is an important aspect, it is not currently perceived as a major barrier to the adoption of digital technologies in agriculture. Furthermore, 21% of farmers highlighted the lack of software management in local languages for data integration and sharing as a challenge.

5.3.3 Analysis of the State of Private Sector Involvement

5.3.3.1 Private Sector Support for Digital Technology Adoption

To better understand the role of the private sector in promoting digital agriculture, agricultural actors were asked whether they had received any form of support from private entities. Out of 100 surveyed farmers, only 25% reported receiving private sector support for adopting digital technologies. Within this group, support from local enterprises was most common (36%). Subsidiaries of retail companies accounted for 24%, with examples such as Indomaret[1] facilitating market-linkage apps or basic digital tools.

Table 5.2. Private Sector Support

Category/source of support	Number of respondents	Share of respondents (%)
Received private support?		
Yes	25	25
If yes, from:		
Multinational companies	4	16
Local farm enterprises	9	36
Startups	0	0
Subsidiaries of retail companies	6	24
No	75	75
Unsure	0	0
Others	9	9

Source: Authors.

Only 16% of farmers benefited from support from a multinational company (e.g. Syngenta offering agronomic decision-support software). Notably, no agricultural actors reported startup assistance, suggesting limited penetration of emerging agri-tech ventures in these communities. Meanwhile, 9% selected 'others', most of whom received digital agriculture support through university-led community service programmes, such as extension workshops or pilot technology deployments. In contrast, 75% of agricultural actors stated that they had not received any support from the private sector, signalling a significant gap in outreach and engagement.

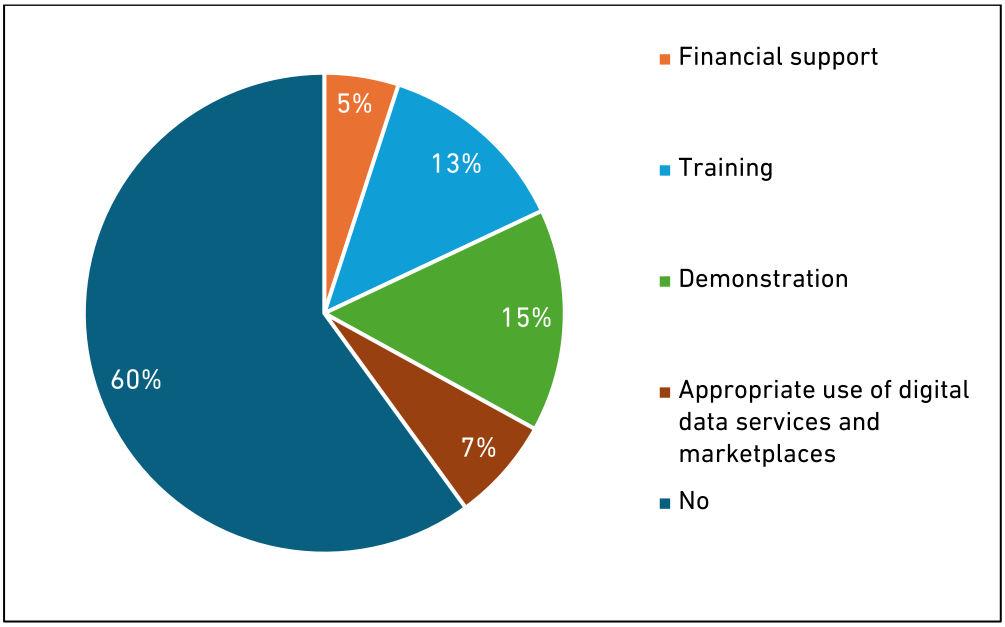
The pronounced gap in private sector engagement, especially the absence of startup involvement, highlights critical opportunities for strengthening public–private collaboration. Agribusinesses and retailers have begun dipping into digital support, but their reach is uneven and often confined to commercial hubs. To accelerate inclusive digital adoption, policies should incentivise startups to co-create solutions tailored for smallholders, such as low-cost sensor networks or mobile advisory services. Likewise, multinational firms and local enterprises could expand community outreach by partnering with universities to scale pilot programmes into sustainable service offerings.

[1] Indomaret is a major retail convenience store chain in Indonesia that has developed partnerships with farmers and agricultural co-operatives to support supply chains and product sourcing. In some cases, these collaborations include assistance in standardising production and using digital platforms for inventory and quality control, making it a relevant example of a subsidiary of a retail company engaging with agriculture through digital solutions.

5.3.3.2 Types of Support Received from the Private Sector

Amongst the 25 farmers who received private-sector support, the most common form of assistance was demonstrations of new equipment, cited by 15% of agricultural actors. This suggests that private actors prioritise hands-on exposure, allowing farmers to see technologies in action before committing to adoption. The second most frequent form of support was training on the use of digital services, reported by 13% of agricultural actors, indicating a strong emphasis on building farmers' capacity to operate and integrate these tools effectively. Appropriate use of digital data services and marketplaces followed, with 7% of farmers receiving guidance on leveraging online platforms and data streams for marketing or decision-making. Finally, financial support for purchasing digital solutions was the least typical, noted by only 5% of agricultural actors, implying that direct subsidies or credit schemes from the private sector remain limited.

Figure 5.12. Support from the Private Sector Received by Farmers



Source: Authors.

5.3.3.3 Deeper Insights

The predominance of demonstrations and training reflects a strategic focus by private sector providers on lowering the knowledge barrier to technology adoption. Companies can foster trust and reduce perceived risks by showcasing equipment and walking farmers through digital workflows. However, the relatively low incidence of financial support highlights a potential bottleneck: even when farmers understand and appreciate a technology's benefits, many may still lack the capital to make the initial investment. Moreover, whilst over one-quarter of supported farmers learn to use data services and marketplaces, this figure suggests that digital market integration remains an under-leveraged opportunity. Ensuring that farmers access technology and translate its outputs into tangible market or productivity gains is critical for long-term sustainability.

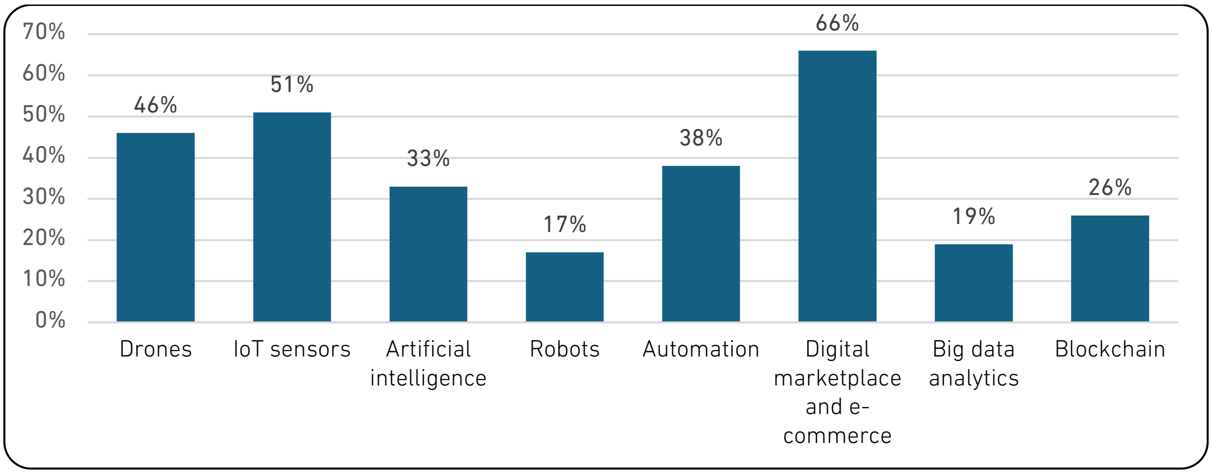
5.3.3.4 Implications for Policy and Practice

To accelerate inclusive digital transformation, public–private partnerships should explore blended support models that combine capacity building (demonstrations and training) with financial mechanisms (micro-grants, leasing schemes, or low-interest loans) to offset upfront costs. Expanding financial support would enable more farmers, especially smallholders, to move from observation to adoption. At the same time, targeted programmes to deepen farmers' data literacy and marketplace navigation skills can help ensure digital tools generate real economic returns. Policymakers can encourage these comprehensive approaches by offering matching funds or tax incentives to private companies that deliver integrated support packages.

5.3.4 Analysis of Expectations of Digital Technologies

Agricultural actors were asked to identify and select all digital technologies they anticipate will exert the most significant medium- to long-term impact on agriculture. The results reveal a clear hierarchy of expectations: 66% of farmers identified digital marketplaces and e-commerce as the most transformative, followed by IoT sensors (51%) and drones at (46%). Other noteworthy technologies include automation (38%), AI (33%), blockchain (26%), big data analytics (19%), and robots (17%). These figures show strong confidence in market-facing and data-driven solutions for future agriculture.

Figure 5.13. Respondents' Perspectives on the Future Need for Digital Technologies



Source: Authors.

5.3.4.1 Spotlight on the Top Three

Digital marketplaces and e-commerce (66%) are pivotal because they directly address market access challenges by connecting farmers to buyers, streamlining logistics, and improving price transparency. Farmers emphasised that these platforms help them expand their market reach, reduce dependence on middlemen, and enable more flexible pricing. Many highlighted the convenience of purchasing agricultural inputs, such as seeds, pesticides, and equipment like pH meters and sprayers, and selling products directly to consumers. Some agricultural actors also mentioned platforms such as Sibakul Jogja,[2] which support the marketing of local agricultural products. The potential of e-commerce lies not only in efficiency and cost-effectiveness but also in empowering farmers to innovate and engage with a broader, more diverse consumer base. For senior farmers, however, digital literacy remains challenging, signalling the need for more inclusive and intensive training.

Next, IoT sensors (51%) promise to revolutionise farm management through real-time monitoring of soil moisture, nutrient levels, and microclimate conditions, enabling precision interventions that boost yields and resource efficiency. Farmers cited the importance of these tools in improving accuracy, especially in measuring key variables such as pH, soil moisture, and temperature, which are considered fundamental to successful cultivation. Several agricultural actors emphasised that accurate data helps prevent guesswork in crop management and enhances overall decision-making. Moreover, some noted the potential of IoT sensors to assist in nutrient regulation (e.g. monitoring parts per million levels), improve water quality assessments, and provide digital records that can guide future interventions. This reflects growing awareness amongst farmers of the role of data-driven agriculture in optimising productivity and sustainability.

Drones (46%) round out the top three by offering scalable aerial monitoring, targeted spraying, and rapid damage assessments, which can dramatically reduce labour costs and environmental impacts. Farmers viewed drones as especially valuable for large-scale operations, noting their effectiveness in fertiliser and pesticide application, saving time and reducing physical labour. Many agricultural actors emphasised that drones improve land monitoring and crop care efficiency, allowing better field observation, especially on wide or difficult-to-reach plots. Others highlighted the ability of drones to support precision mapping and post-harvest assessment. This reflects increasing recognition amongst farmers that drones are not just high-tech tools but practical innovations that directly support day-to-day productivity and modernise traditional farming practices. Together, these three technologies form a powerful toolkit for enhancing productivity, resilience, and profitability across diverse ASEAN farming systems.

5.3.4.2 Emerging and Supporting Technologies

Beyond the top three, automation (38%) and AI (33%) are widely viewed as the next wave of innovation, with applications ranging from autonomous machinery to predictive analytics for pest and disease outbreaks. Blockchain (26%) holds promise for traceability and supply chain integrity, particularly in high-value or export-oriented commodities.

[2] Sibakul Jogja is a digital platform developed by the Regional Government of the SRY to support local micro, small, and medium-sized enterprises, including farmers, in marketing their products. The platform aims to facilitate online sales, improve market access, and optimise income for local producers through digital channels.

Meanwhile, big data analytics (19%) can integrate disparate data streams, including market trends, weather forecasts, and satellite imagery, into actionable insights for policymakers and agribusinesses. Although less common, robots (17%) may eventually support labour-intensive tasks such as harvesting or weeding in specialised cropping systems.

5.3.4.3 Implications for Policy and Practice

These preferences underscore the need for a holistic digital strategy in ASEAN agriculture. Governments and development partners should prioritise investments in digital marketplace platforms, ensuring rural connectivity and secure payment systems to maximise adoption levels. Simultaneously, scaling up IoT infrastructure through subsidies for sensor networks or open-source data platforms will be critical for enabling precision farming at scale. Regulatory frameworks for drone usage, including airspace management and training certification, must be streamlined to unlock their full potential. Encouraging public–private partnerships can also accelerate the deployment of AI, automation, and blockchain solutions. At the same time, capacity-building programmes should equip farmers with the skills to interpret and act on complex data outputs. By aligning infrastructure, policy, and human capital development, ASEAN countries can translate these technology priorities into tangible gains in productivity, sustainability, and rural livelihoods.

5.4 Policy and Government Initiatives and Programmes for Promoting the Utilisation of Digital Technology in Agriculture in Indonesia

5.4.1 Policy and Government Initiatives for Promoting the Utilisation of Digital Technology in Indonesia

The Ministry of Agriculture of Indonesia enacted the regulation named Permentan No. 16/2013, which initiated the utilisation of digital technology in Indonesia by issuing guidelines for the management system for agricultural extension. The regulation aimed to accelerate the extension of agricultural information effectively and efficiently. Agricultural information should meet four requirements: the right time, the right place, the right target, and the right needs. The database containing information on farmers and extension workers at local, regional, and national levels has been updated electronically on the internet to enhance agricultural productivity. The number of farmers in Indonesia was stored on the Management Information System application, SIMLUHTAN, to identify the targets of extension workers. Extension workers can create tailored materials based on local farmers' commodities and issues. The cyber extension website was utilised to disseminate extension workers' materials to farmers across Indonesia. Using the cyber extension, materials from extension workers can be stored and verified before they are communicated to farmers. The verified materials become part of a government database and enrich the resources needed by farmers. Permentan No 16/2013 was reinforced by

Permentan No 47/2016, which emphasised the importance of the database. The function of the agricultural data centre and information system was further developed. The Satu Data Pertanian programme (One Agricultural Data Initiative), focuses on providing valid and reliable data. The data are used to consolidate agricultural data, including production, land area, and farmer identity, into a centralised and interoperable system. It also supports transparency and synchronisation across ministries, local governments, and private sector stakeholders (Sitanggang and Sampurna, 2023).

Based on a new regulation, Permentan No.27/2023, the Indonesian government regulated the utilisation of ICT to ease farmers' and farm business actors' access to information sources, technology, and other valuable resources for their activities. To improve the utilisation of ICT, the government facilitated training to enhance the capabilities of extension workers whilst also providing ICT infrastructure. At this stage, the most significant challenges were the low digital literacy levels of farmers and extension workers and limited internet access in rural and farming areas. Meanwhile, in 2017, an innovation for distributing subsidies to the right targets was introduced through Kartu Tani, or the Farmer Card. Kartu Tani is a debit card that farmers can use to access fertiliser subsidies directly from input shops or distributors. According to Nomita and Ramadhoni (2022), the implementation of Kartu Tani is considered complex by farmers without guidance from extension workers. The strength of Kartu Tani lies in its integration of data on fertiliser access and input needs. It reflects the government's efforts to monitor subsidy distribution whilst also introducing technology in the financial aspect of agriculture. The government, private sector, community, and academia have jointly implemented an online advisory approach. Most farming advisory applications used for this purpose are Android-based. For instance, the Faculty of Agriculture of Universitas Gadjah Mada introduced DESA Apps (Digital Extension Society for Agriculture) as an interactive discussion platform to help farmers solve various farming problems in the field. The online members of Desa Apps come from 35 provinces in Indonesia, totalling more than 14,500 members. Meanwhile, one private sector actor that assists farmers through the advisory application is the seed producer PT East West Seed Indonesia, through an application called SIPINDO. This application provides recommendations on fertiliser dosage and seed requirements.

5.4.2 Accelerating Digital Technologies and Precision Agriculture Initiatives

Starting in 2020, the Ministry of Agriculture in Indonesia promoted a strategic plan to accelerate the utilisation of digital technologies in agriculture. This was also triggered by the COVID-19 pandemic, which led to the increased use of digital technology due to limited face-to-face meetings with farmers. Other conditions also encouraged the use of digital technology, such as the improved development and accessibility of internet networks, climate change, the need to add value, the need to extend marketing networks, and the emergence of young farmers. The era of disruptive innovation in the Industrial Revolution 4.0 has forced the government to change how it develops agriculture, as digital transformation is a key driver of agricultural modernisation. The Indonesian government enacted the National Medium-Term Development Plan (RPJMN) 2020–2024 and 2025–2029, prioritising the theme of smart agriculture for sustainable food security. Under this framework, the Ministry of Agriculture issued a strategic plan to achieve modern agriculture. The Government of Indonesia has recognised the critical role of modern agriculture, implemented through precision agriculture, in mitigating climate change that can contribute to stagnating productivity, pest outbreaks, and inefficient input usage. Accordingly, government initiatives to accelerate remote sensing for land size mapping, drone technology for mapping, precision spraying, pest surveillance, and IoT-based irrigation systems enable real-time water management based on soil moisture sensors and weather forecasts. The strategic plan referred to the Ministry of Agriculture, which has supported the enactment of an electronic-based government system (SPBE), regulated under Permentan No. 33/2023 and Permentan No. 05/2024. Following this, the Directorate General of Infrastructure and Facilities of the Ministry of Agriculture (Ditjen PSP) launched a master plan for precision agriculture. Precision agriculture emphasised the utilisation of high technology, data-intensive farming practices, and digital solutions suited to Indonesia's socio-economic diversity. The first step in the plan is to determine appropriate locations by conducting a survey investigation design (SID) and site mapping. After that, site plan management involves the participation of farmer groups or associations of farmer groups, along with infrastructure development and rehabilitation through the installation of smart irrigation, robots, and drone sprayer trials. In 2023, in Sleman Regency, one of the districts in the SRY, a geospatial mapping programme was trialled for rice fields. Based on the research results of Azizah, Hariadi, and Raya (2024), farmers' responses to the implementation of geospatial mapping for rice fields were highly positive. This was influenced by the role of extension workers, programme socialisation, farmers' perceptions of land mapping, and educational level. The Ministry of Agriculture established the Agriculture War Room (AWR), equipped with computers, an internet connection, and a meeting room to consolidate data on rice field size, fertiliser needs, and harvest area. The AWR was built in every subdistrict, and extension workers are responsible for its implementation. To develop the AWR, the Ministry of Agriculture collaborates with the Ministry of Agrarian Affairs and Spatial Planning, the National Land Agency, Statistics Indonesia, the National Institute of Aeronautics and Space, and the Geospatial Information Agency. The Indonesian government also plans to apply precise fertiliser dosages through Site-specific Nutrient Management to provide information on the specific conditions of farm plots using GIS and algorithms. In addition, an Early Warning System is being implemented in some areas of Indonesia for pest control management. GIS GEODATA, an application used in Central Java, supports disease mapping, analysis of disease dynamics, and prediction of disease outbreaks (Prasetyo et al., 2017).

5.4.3 Challenges in Promoting the Utilisation of Digital Technology in Agriculture

Although regulation regarding the utilisation of digital technology in agriculture has been enacted and trialled in some locations and regions, the data from the previous sections suggest that some challenges remain, including infrastructure, human resource capacity, financial barriers, and policy co-ordination. The infrastructure challenges include inadequate electricity supply and a limited internet connectivity. Only 28% of farmers have consistent access to electricity, which hampers the use of digital devices for smart irrigation and drones. In addition, digital literacy remains low. Only 30% of farmers demonstrated sufficient digital skills. Small-scale farming limits the economic viability of adopting technology. Meanwhile, older farmers face more difficulties with digital skills than younger farmers. Moreover, the training in digital literacy is limited, and the digital skills of extension workers are similar to those of farmers. Digital human capacity is needed not only by farmers but also by extension workers. On the other hand, financial constraints are the most common barriers to adopting technology in agriculture. More than 50% of farmers declared that the cost of digital tools, such as drones and smart sensors, is a major obstacle, whilst access to financial loans, grants, or microcredit for digital tools is also lacking. It has become increasingly difficult for farmers to procure digital tools in agriculture by themselves. If good collaboration amongst private, public, and community partners is achieved, the utilisation of digital technologies in agriculture can proceed smoothly. Addressing these challenges requires a comprehensive and integrated approach that combines infrastructure investment, capacity building, financial innovation, policy reform, and multi-stakeholder collaboration.

5.5 Way Forward

The study's conclusions support the promise of digitalisation to improve resilience, sustainability, and production in Indonesia's food and agricultural systems. However, to achieve this promise, enduring issues related to digital literacy, infrastructure, financial accessibility, institutional coherence, and stakeholder co-ordination must be resolved. This section builds on the findings of the field survey by suggesting a strategic roadmap to hasten the adoption of digital technologies in the agriculture and food sector whilst ensuring that appropriate interventions are sustainable, inclusive, and adapted to local conditions and characteristics.

1. Improving Digital Infrastructure in Rural Areas

The study emphasises that a significant obstacle to adopting digital technologies is the availability of dependable electricity and broadband connectivity. It has been noted that only 15% of farmers have reliable internet connectivity, and only 28% reported regular access to electricity. These shortcomings limit the utilisation of e-commerce platforms, precision agricultural equipment, and digital advisory platforms. To provide farming communities with reliable access to electricity and internet connectivity, it is imperative to implement the following measures:

a. Expand rural electrification projects by utilising renewable energy sources, such as localised solar systems.

b. Establish public–private partnerships to develop broadband infrastructure and encourage internet service providers to offer reasonably priced connectivity to underserved agricultural areas.
c. Create community digital hubs, such as Digital Agriculture Hubs or enhanced Agriculture War Rooms, where farmers can access digital training, internet connectivity, and advisory assistance. Many rural farmers will continue to be unable to take advantage of and benefit from digital technology without this fundamental infrastructure upgrade.

2. Enhancing Digital Literacy and Capacity Building

A main conclusion of the survey is that farmers and agricultural extension agents have low levels of digital literacy. Only 30% of farmers showed they had the digital skills necessary to use contemporary farming equipment efficiently, whilst extension agents also showed the significant competency gaps. Therefore, a complete human capital development agenda is required to execute targeted digital literacy programmes for farmers, with an emphasis on basic ICT usage, mobile advisory platform navigation, data interpretation, and e-commerce involvement. Digital agriculture modules should be incorporated into training and certification programmes to improve the skills of agricultural extension employees. Working and collaborating with academic institutions, including Universitas Gadjah Mada's Faculty of Agriculture, can be one alternative solution for creating interdisciplinary blended courses that combine business management, agronomy, and digital skills. Encouraging peer-learning programmes in which tech-savvy farmers guide others in their communities to promote the rapid spread of skills is also essential. To guarantee that technology advancements result in tangible benefits, it is crucial to have a workforce in agriculture that is proficient in digital technologies, including field agricultural extension workers, farming group leaders, leading millennial farmers.

3. Expanding Financial Access for Digital Technology Adoption

More than 70% of farmers cite high upfront costs as a significant barrier to digital adoption, making financial hurdles one of the main obstacles still present. Smallholder farmers frequently lack the funds to purchase cutting-edge technologies like drones, IoT sensors, and precision farming equipment. Microcredit and lease programmes that allow farmers to access digital technologies with little initial investment should be included as part of prospective policy measures. Establishing guarantee funds backed by the central and/or local government can lower the risk for lenders providing loans for projects in digital agriculture. Supplying matching funds or tailored grants to farmer groups implementing validated digital technologies can further support adoption. This can be achieved by creating cutting-edge financing schemes that combine market linkage initiatives or access to agriculture insurance with technology. Smallholder farmers must be empowered by financial interventions designed to ensure that their financial limitations do not prevent them from enjoying the advantages of digitalisation.

4. Promoting Policy Coherence and Institutional Co-ordination

According to the survey, two major obstacles are inconsistent policies and inadequate co-operation between the central and local governments. Farmers often face disjointed programmes and shifting regulatory landscapes, which erode trust and continuity. To address this issue, a National Task Force for Agricultural Digitalisation should be created, bringing together officials from academia, the corporate sector, and relevant ministries to co-ordinate the development of policies, their implementation, and oversight. To guarantee data standardisation, interoperability, and accessibility across various governmental levels, the One Agricultural Data (Satu Data Pertanian) project should be strengthened and operationalised. To ensure that farmers and service providers work in a predictable environment, clear and stable legislative frameworks governing emerging technologies, such as drones, digital payment systems, and agri-data management, are needed. Furthermore, developing strategic plans that connect digital agriculture projects to broader national development objectives, including climate resilience, rural development, and food security, is essential. A robust digital agriculture ecosystem also depends on efficient governance.

5. Strengthening Public–Private Partnerships for Innovation

Only 25% of farmers said that private sector organisations had helped them use digital tools. This indicates huge unrealised potential for greater involvement from the corporate sector. Private businesses, especially startups and agri-tech companies, should be encouraged to provide locally relevant, reasonably priced, and farmer-friendly digital solutions. This involves supporting pilot project initiatives that are co-financed and combine farmer participation, public sector facilitation, and private sector innovation along with establishing competitive award programmes and innovation hubs to promote the creation of significant, scalable digital solutions. This should be followed by collaboration with agribusinesses to provide supply chain partners with market platforms, traceability systems, and digital extension services. Digital advances in the agriculture and food sector can be expanded quickly and sustainably by strengthening ties between farmers and the corporate sector.

6. Prioritising Inclusivity in Digital Transformation

To avoid escalating rural disparities and the digital divide in farming, digital agriculture initiatives must prioritise inclusion strategies. This includes creating user-friendly apps with low-bandwidth settings and compatibility with simple mobile phones. Outreach and training initiatives should be adapted to the needs of female farmers, who frequently encounter additional obstacles when trying to utilise technology. Young people should be actively involved in agriculture through digital entrepreneurial initiatives that leverage their higher levels of digital fluency. Relevant institutions should develop locally relevant and accessible materials in local languages. Ensuring that digitalisation benefits all groups in rural areas is essential for achieving equitable agricultural development.

7. Developing Robust Data Systems for Smart Decision-Making

Accessible, timely, and accurate information is essential for data-driven agriculture. Soil mapping, climate forecasts, and market trends are amongst the crucial data services that many farmers cannot access. Important next steps include the development of predictive analytics tools for crop optimisation, weather risk mitigation, and pest management; the expansion of IoT sensor networks to gather real-time farm data and integrate them into open-access platforms; and the promotion of digital traceability systems that improve food safety, quality assurance, and access to premium markets. Collaboration and partnerships amongst the business sector, legislators, government agencies, universities, research institutions, and farmers can support better and more sustainable decisions through robust data systems.

This research affirms that harnessing digitalisation is not merely an option but a strategic necessity for building a resilient and sustainable agricultural system in Indonesia. Digital transformation in the agricultural sector must be implemented inclusively and collaboratively, involving all stakeholders, including the government, private sector, academia, and farmers themselves. Through targeted investments in infrastructure, enhanced digital literacy, access to financing, and strengthened regulations and partnerships, Indonesia can accelerate the adoption of digital technologies to improve food security and promote environmental sustainability. In this way, efforts to harness digitalisation for resilient and sustainable agriculture will truly become a milestone in advancing Indonesia's agriculture in the digital era.

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Chapter 6

Preliminary Assessment of Digitalisation for Sustainable Agriculture and Food Systems in Lao PDR

Sayvisene Boulom, Sian Phommaluesa, Thansamay Dethpakhouan, Souliyuan Viengkhamsone, Kangbao Xaytouthao, and Saysouda Lasakit

6.1 Introduction and Background

Population growth, weather extremes, pests, land degradation, and market disruptions are straining agriculture and food systems globally, regionally, and locally. The projected population of the Association of Southeast Asian Nations (ASEAN) of 723 million by 2030 intensifies pressure on food security, water resources, and agricultural labour. Agriculture plays a pivotal role in the economies of Lao PDR and the ASEAN region, contributing significantly to both employment and gross domestic product (GDP). The agriculture sector contributed about 21% to the GDP of Lao PDR in 2023 (Bank of the Lao PDR, 2023).

To address these challenges, the application of advanced digital technology in agriculture is essential for future resilience and productivity. As a concerted and collective initiative, the 'ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector' were adopted by the ASEAN Ministers on Agriculture and Forestry in 2021 (ASEAN, 2021). In addition, in the 'ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises', adopted at the ASEAN Summit in September 2023, ASEAN leaders agreed to accelerate digital transformation to increase productivity and resilience in agri-food systems.

Digital transformation has created opportunities for agri-food systems to monitor and manage global soil, climatic, and genetic resources, as well as to share information amongst stakeholders along agri-food value chains (Anbumozhi et al., 2022). Applying digital technologies in agriculture, such as artificial intelligence (AI), automation and robotics, sensors, the Internet of Things (IoT), and data analytics, can help reduce waste, improve farming inputs, and boost crop production. This represents a shift from traditional operations to continuously automated processes, resulting in higher agricultural production by enabling the traceability of products and processes. The application of digitalisation provides farmers with accurate and real-time observations of their practices, enhancing productivity through improved monitoring of plant health, soil quality, weather conditions, and pest and disease pressure (Abiri et al., 2023).

Figure 6.1. Digital Technology Applications Along the Agri-food Value Chain

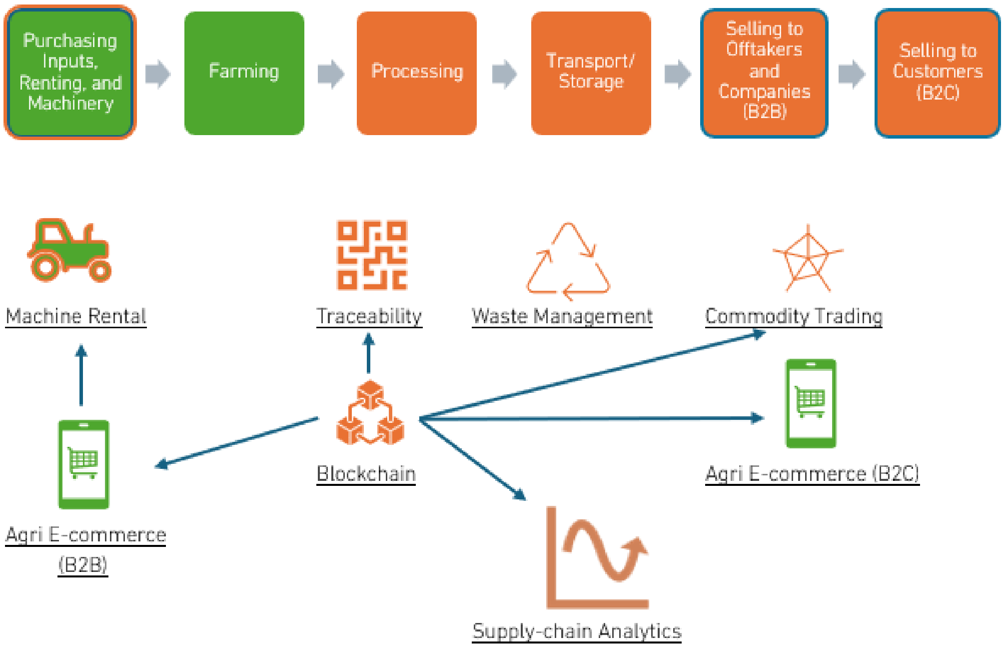
Digitalisation in production	Digitalisation in supply chains	Digitalisation in finance
•Sensor and remote sensing •Drones •Farmer advisory •Crop analytics •Pest/disease management •Machine rental	•Ingredients and food biotechnology •Smart packaging •Traceability •Waste management •E-grocery and commodity trading •Restaurant bookings and mealkits •Blockchain •In-store logistics	•Digital payments •Insurance •Agri e-commerce (B2B, B2C) •Supply chain analysis

Source: Authors, modified from Montesclaros and Teng (2023).

Innovative and digital technologies are important tools for adapting the agricultural sector to climate change and responding to the rising demand for agriculture to serve as a key sector for food security, income, trade, and employment in the region (Figure 6.1). Building on their role in improving productivity and resource management, these technologies contribute to agricultural development (Montesclaros and Teng, 2023).

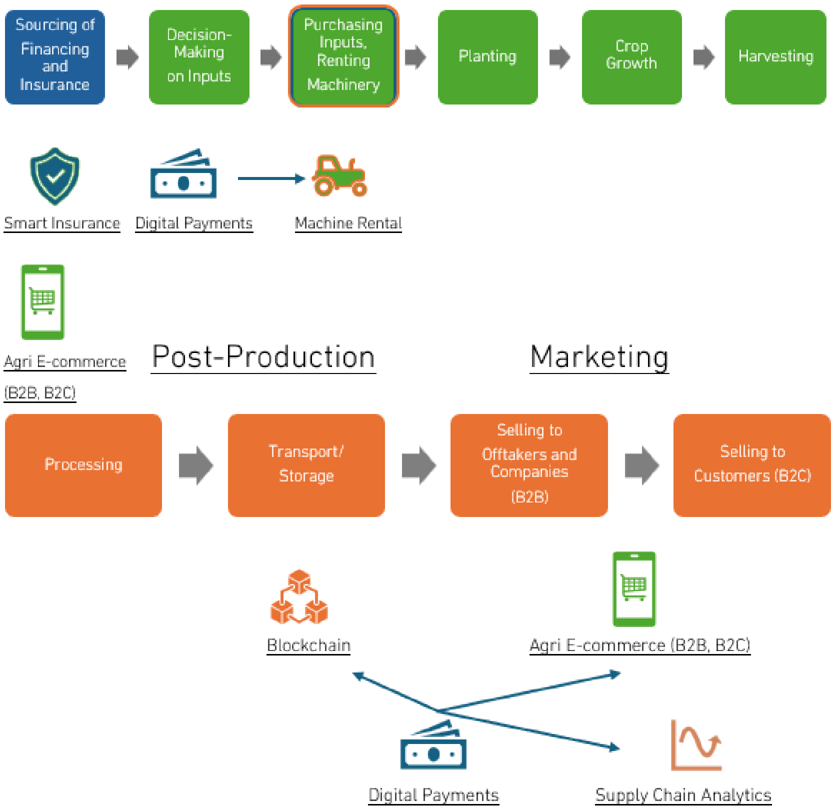
Montesclaros and Teng (2023) also demonstrated the application of blockchain technology and digital payment systems within agricultural supply chains. They emphasised that increasing access to financing for farmers is a way to promote digital finance alongside other digital applications, such as e-commerce and traceability systems (Figures 6.2 and 6.3).

Figure 6.2. Blockchain Technologies Within the Supply Chain



Source: Authors, modified from Montesclaros and Teng (2023).

Figure 6.3. Digital Payments in the Supply Chain



Source: Authors, modified from Montesclaros and Teng (2023).

Digital technologies are promoting the transformation of smallholder farmers by improving access to knowledge, increasing productivity and income, and strengthening food security (Abdulai et al., 2023). Therefore, follow-up actions are needed. This study is conducted as a means of reinforcing and supporting these initiatives.

6.2 Objectives

The questionnaire survey formulated in this study targets farmers, technology providers, and other stakeholders, including businesses in ASEAN Member States. The objectives of the study are to:

1. Assess the actual status of utilisation of digital technologies in the agricultural value chain;
2. Identify challenges to the diffusion of digital technology utilisation in agriculture and food systems; and
3. Identify and analyse digital policy instruments for strengthening agriculture policies.

6.3 Methodology

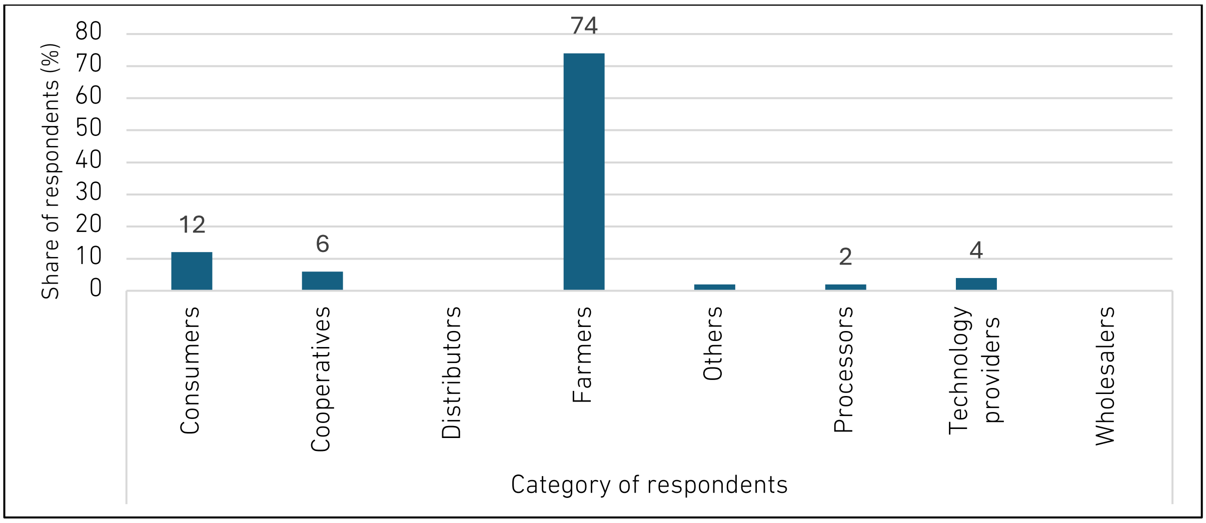
The locations of this study were selected in Vientiane Capital, which includes some of the most important agricultural production areas and is close to major city and markets in Vientiane Capital, Lao PDR. Sample selection was conducted using a purposive sampling method. The research team first sent official letters to the Provincial and District Agriculture and Fishery Offices to facilitate access to potential respondents. These offices then co-ordinated with village heads to identify relevant participants and arrange appointments with farmers and other respondents. The selected respondents included local rice, vegetable, and aquaculture producers, as well as representatives from academia, collectors, and traders, ensuring coverage of key actors across the agricultural value chain. Participation in the interviews was voluntary. The data were mainly analysed using descriptive analysis.

6.4 Study Results

6.4.1 Respondent Information

The study of agricultural digitalisation was conducted mainly in Vientiane Capital, where new innovative technologies have been applied in production, trade and communication. The results of the preliminary survey were obtained from a total of 100 respondents, including 74 farmers, 12 consumers, 6 co-operatives, 4 technology providers, 2 processors, and others (Figure 6.4).

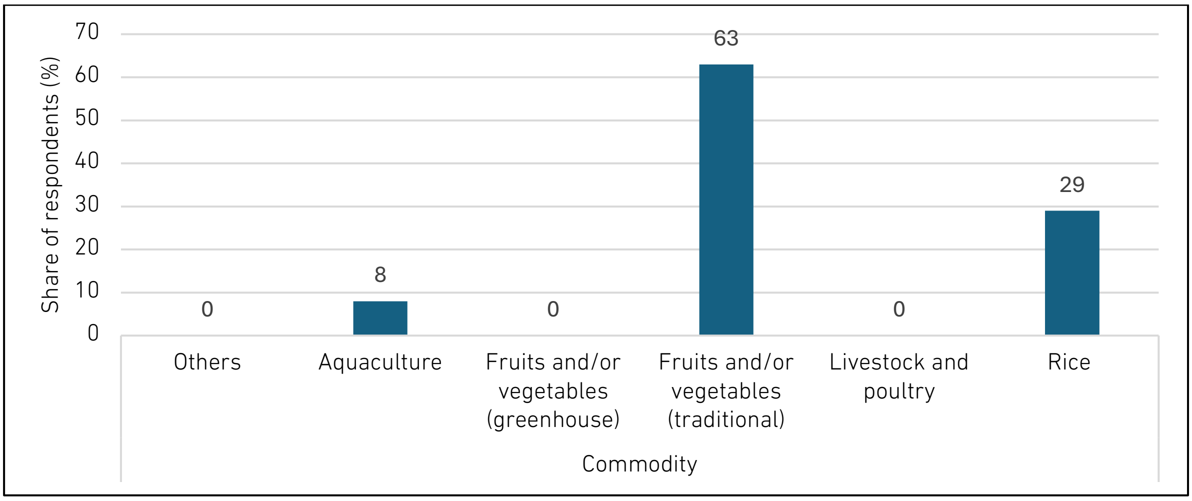
Figure 6.4. Category of Respondents



Source: Authors.

Of the 74 farmer respondents who participated the survey, digital technologies had been applied in different fields. The three main fields were traditional fruits and vegetables, rice production, and aquaculture which represented 63%, 29%, and 8%, respectively (Figure 6.5).

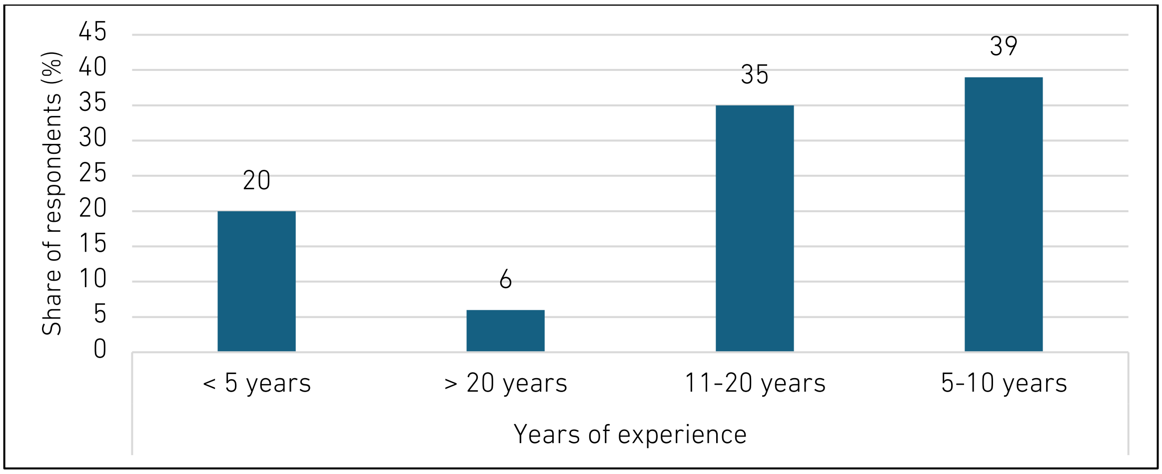
Figure 6.5. Commodities of the Farmers



Source: Authors.

In this survey, the experience of respondents, including farmers, was investigated. The respondents were grouped into two main categories. For instance, 39% of respondents had 5–10 years of experience in agriculture and related fields, and 35% had 10–20 years of working experience. Young people working in agriculture accounted for only 20% of respondents, whilst 6% had long-term experience (Figure 6.6).

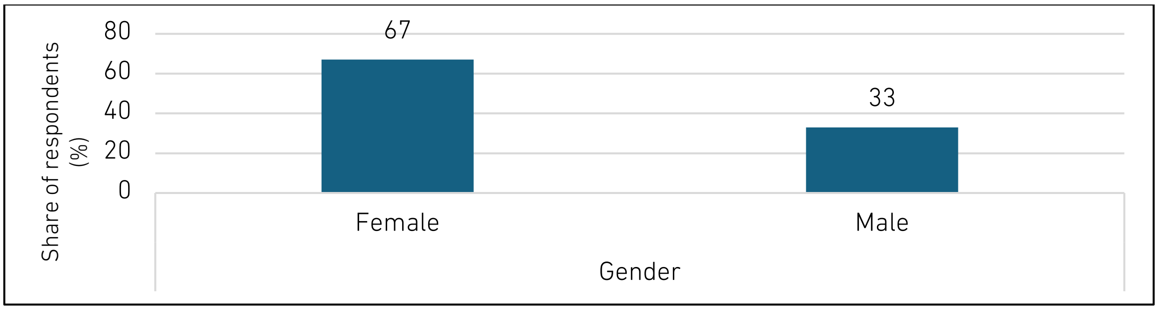
Figure 6.6. Years of Experience



Source: Authors.

From the survey, it can be observed that more women participated in the agricultural digitalisation study and applied innovative technologies in Lao PDR. The results of the survey revealed that 67% of respondents were female, whilst 43% were male (Figure 6.7). Evidence from Nigeria further demonstrates that mobile phone-based agricultural services can deliver gender-responsive benefits. Male farmers mainly used mobile phones to access timely agricultural information to support production and market decisions, whereas female farmers relied on mobile communication to reduce travel and transaction costs by accessing agricultural and financial services remotely (Kayode et al., 2023).

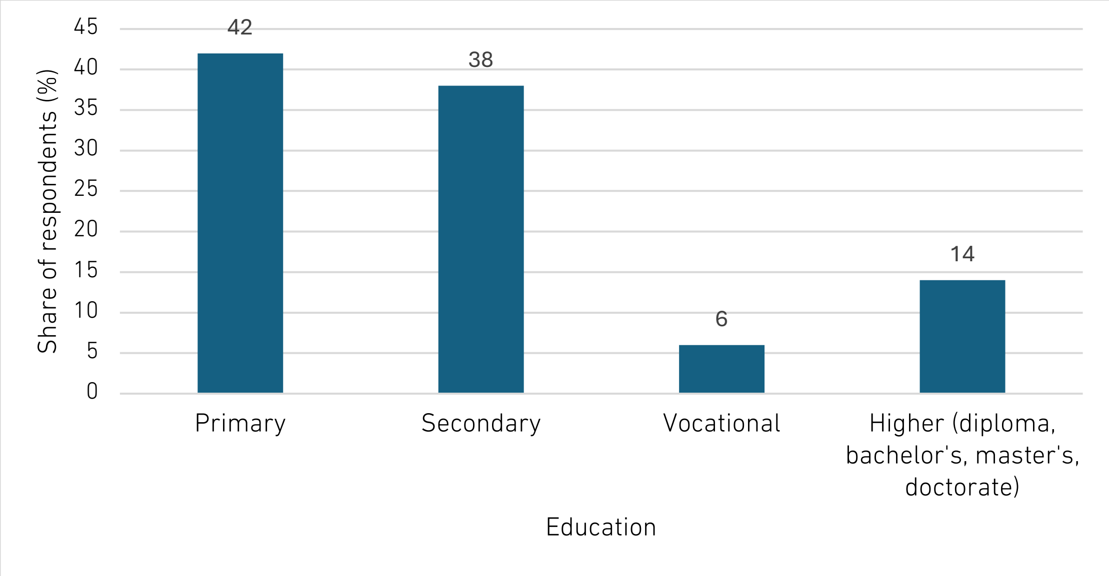
Figure 6.7. Gender of Respondents



Source: Authors.

The survey results show that education level influences the application of digitalisation in agriculture. A study in China found that higher education levels amongst rural labour have a positive effect on promoting agricultural digitalisation and high-quality agricultural development (Tang and Chen, 2022). The survey further revealed that the majority of respondents had completed primary education (42%) and secondary education (38%), whilst higher education levels, such as diplomas, bachelor's, master's, and doctoral degrees, accounted for only 14%. It can be concluded that Lao farmers had comparatively low literacy levels, which may impair participation in digital services and adaptation.

Figure 6.8. Education Level of Respondents



Source: Authors.

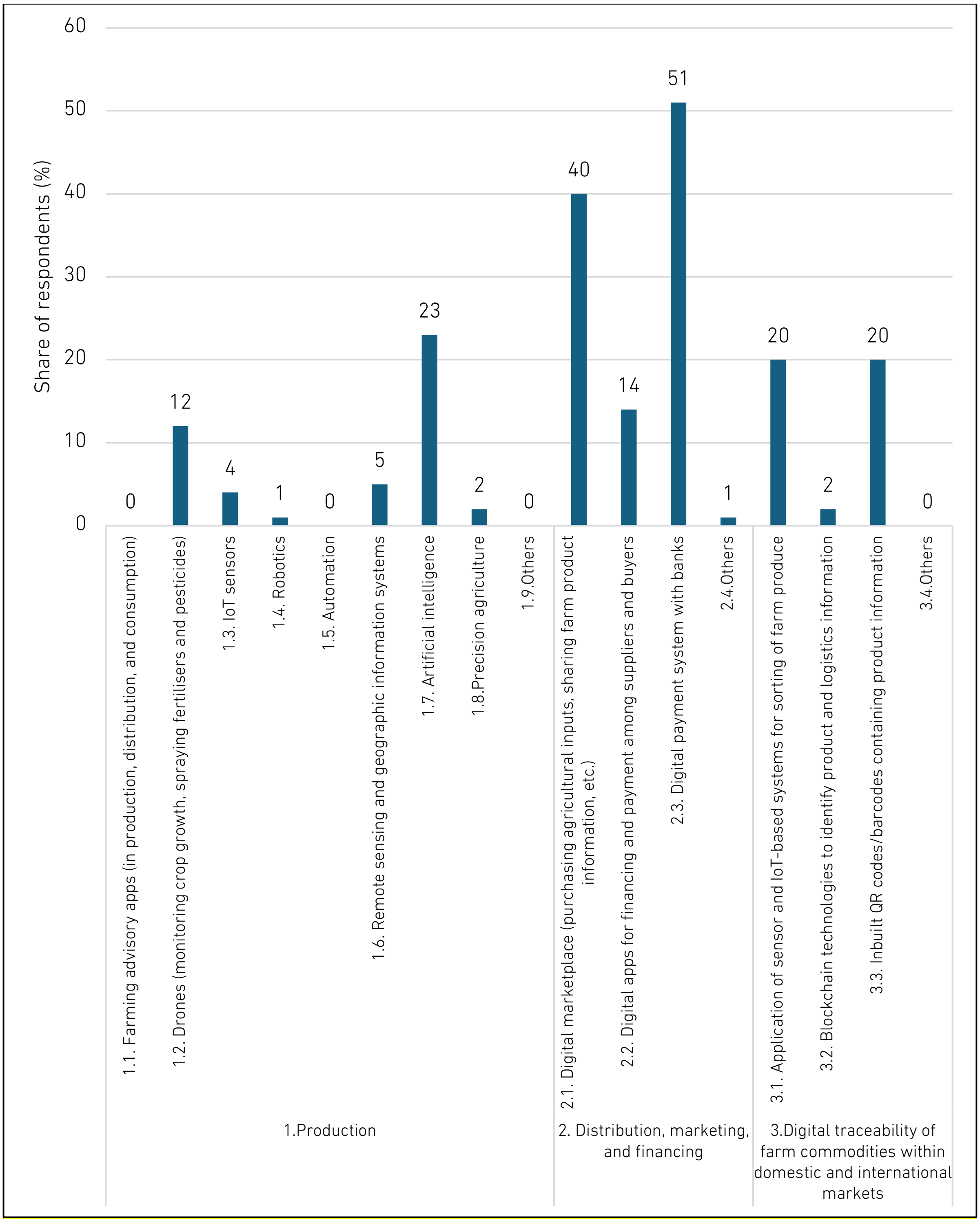
6.4.2 Current Status of Utilising Digital Technologies and Tools in Agricultural Production and Along the Food Value Chain

6.4.2.1 Available Digital Technologies and Tools Used in Farming Activities and/or Activities Along the Food Value Chain

Agricultural AI and digital technologies are commonly referred to as agri-tech or smart agriculture. These technologies aim to transform agricultural practices through machine learning, data analysis, pest and disease prevention, and the optimisation of agricultural production. This survey focuses on digitalisation in agriculture across three key aspects: production; distribution, marketing, and financing; and digital traceability of farm commodities. The results presented in Figure 6.9 show that digitalisation tools are currently being applied in agriculture in Lao PDR. To begin with, digital technologies used in agricultural production systems include AI, drones, remote sensing and geographic information systems (GIS), ICT sensors, and precision agriculture. AI applications in agriculture in Lao PDR include data collection and analysis, as well as the identification of soil health conditions, pests, and diseases. Drone applications are a relatively new technology for smallholders and have been used to spread rice seeds and fertiliser, helping to address labour shortages in Lao PDR. In addition, GIS systems have been applied in land-use planning, agricultural zoning, and land titling.

More recently, digital traceability of farm commodities within domestic and international markets has been identified as a new trend in Lao PDR. Both the Department of Agriculture, Ministry of Agriculture and Forestry and the Department of Intellectual Property, Ministry of Industry and Commerce (MOIC) have been promoting product safety and quality in Lao PDR; therefore, traceability systems are required. Based on current practices, respondents indicated that they have started creating QR codes to represent their farms and products. Some e-commerce platforms, supermarkets, and distributors, such as AgriLao, J-Mark, and View Mall, have applied sensor- and IoT-based systems to manage their stocks and sales.

Figure 6.9. Use of Digital Technologies and Tools

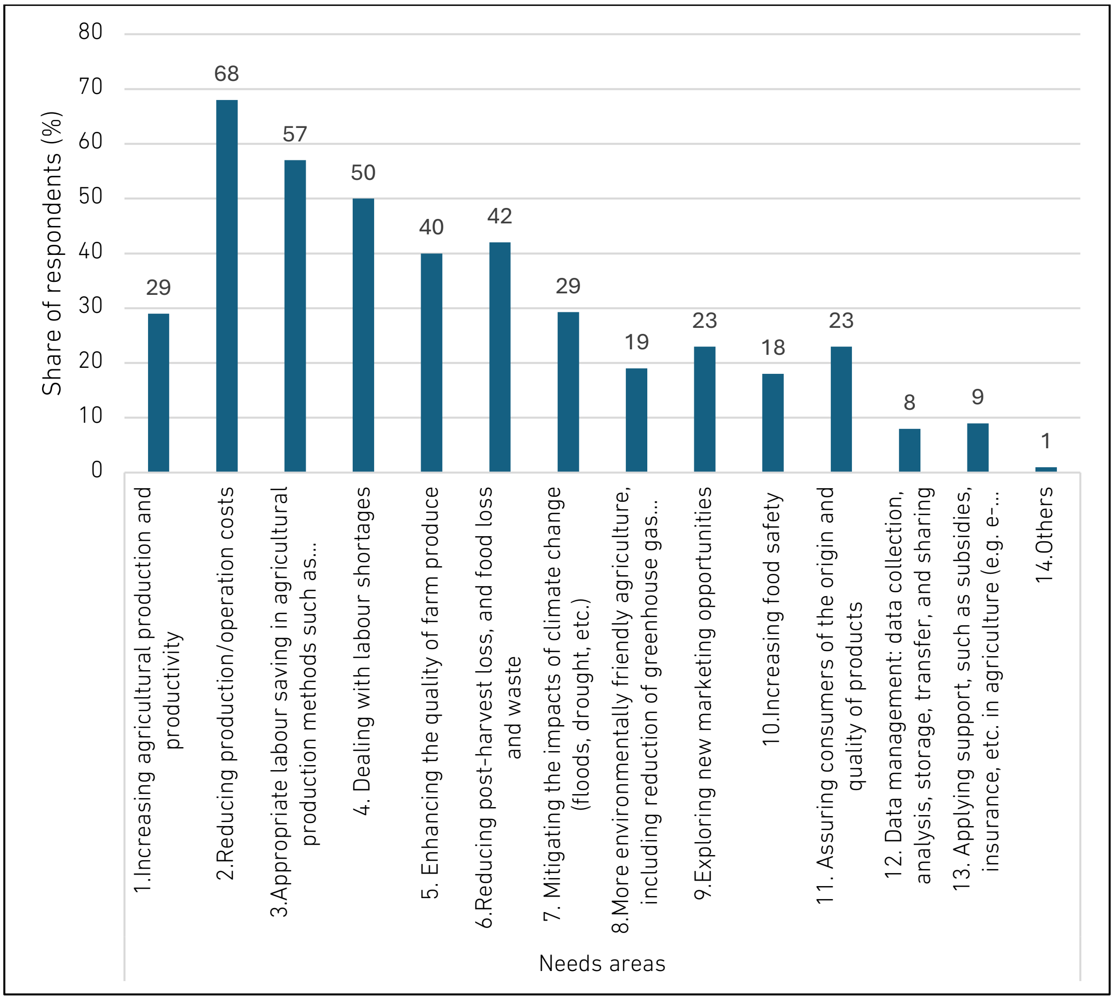


Source: Authors.

6.4.2.2 Needs Areas in the Agriculture and Food Value Chain

Digital technologies in agriculture can increase farm performance by enhancing sustainability, productivity, and resilience, particularly through IoT technologies, sensors, data analytics, and decision support systems, leading to more tailored and precise farming operations. In the case of Lao PDR, the areas most in need of digitalisation solutions in agriculture are, first, reducing production or operational costs. Second, digital applications must be leveraged to optimise the use of agricultural inputs like fertiliser, water, and animal feed. After COVID-19, labour shortages became more serious in Lao PDR, as young workers migrated to Thailand, the Republic of Korea, and Japan. Therefore, new agricultural practices require new technologies to mitigate labour shortages. Lao farmers are seeking new harvesting technologies to reduce losses during harvest. For example, they hire combine harvesters from agricultural service companies to operate in the fields, saving time and maximising rice yields. Finally, climate change frequently affects agricultural production in Lao PDR. Apart from utilising digital agriculture technologies, farmers also need new climate-resilient crop varieties that are adapted to severe heat during the dry season or can withstand flooding during the rainy season (Figure 6.10).

Figure 6.10. Needs Areas in Agriculture and Food Value Chains



Source: Authors.

6.4.2.3 Challenges, Constraints, and Obstacles to Using Digital Technologies and Introducing Digital Solutions

The utilisation of digital technologies and the introduction of digital solutions have been initiated in Lao PDR. However, the promotion and adoption of these technologies have lagged behind other ASEAN countries (Montesclaros and Teng, 2023). The challenges, constraints and obstacles to adopting agricultural digital technologies have been identified in this study. Five key areas were analysed: basic infrastructure, human resources, financial constraints, institutional factors, and digital data management and information transfer.

The main basic infrastructure challenges identified were farmers' land size and climate-induced disasters. Lao farmers have small plot sizes, and although the concepts of enlarging rice plots and levelling land using sensors have been introduced in Lao PDR, many farmers cannot afford the associated costs. In recent years, climate change has occurred more frequently and has caused storms, floods, and droughts, which have damaged infrastructure. Based on respondents' answers, the most common infrastructure-related challenges are small farm sizes and climate-induced natural disasters, whilst limited access to stable electricity supply and internet connectivity are considered less significant barriers. In addition, farmers have not widely adopted modern mechanisation and continue to rely on simple equipment and tools (Figure 6.11).

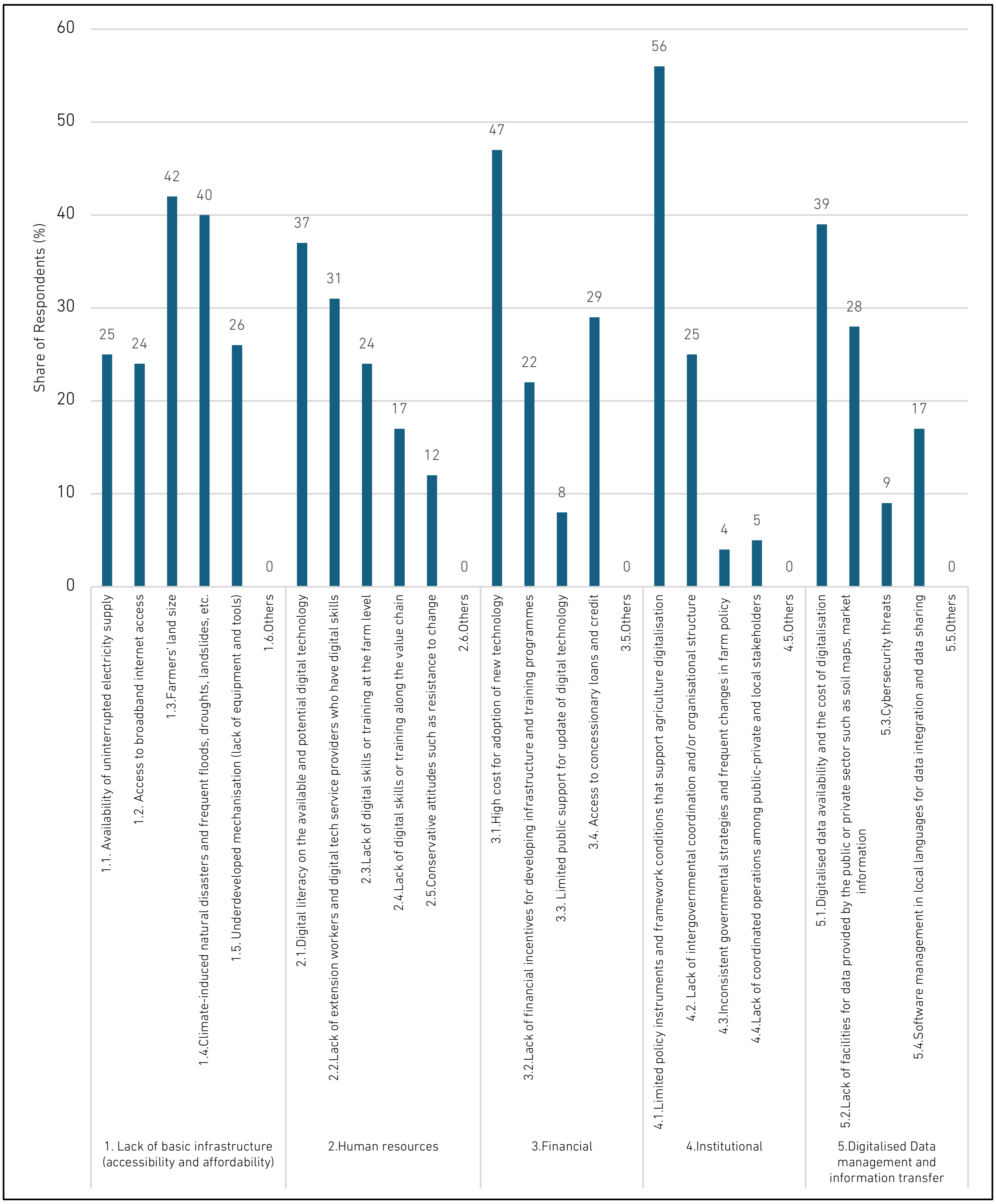
Another challenge in implementing digital technology in agriculture is the substantially low number of technical staff with adequate knowledge and skills. The survey results show that less than 40% of respondents have digital literacy. In addition, the study found a lack of digital extension services and limited digital training at the farm level.

Providing financial support could help remove technical and technological barriers to agricultural digitalisation, enabling technical staff to plan and improve methods and technologies (Faskhutdinova et al., 2020). Respondents reported that applying new and modern technologies is expensive, whilst the lack of financial incentives to develop infrastructure and provide training remains a significant challenge.

Another obstacle identified by Lao farmers is limited access to loans and credit for technological adaptation. Although government policies in Lao PDR aim to enhance sustainable agricultural development, including green, clean, and modernised agricultural practices, institutional enforcement remains limited. Respondents reported that two major institutional challenges are limited policy instruments and frameworks to support agricultural digitalisation, as well as a lack of intergovernmental co-ordination.

Finally, data management and utilisation remain major challenges in Lao PDR. Collecting agricultural production and trade data requires high costs, and data storage in cloud systems is generally managed by private companies and is also costly.

Figure 6.11. Challenges, Constraints and Obstacles to Using Digital Technologies



Source: Authors.

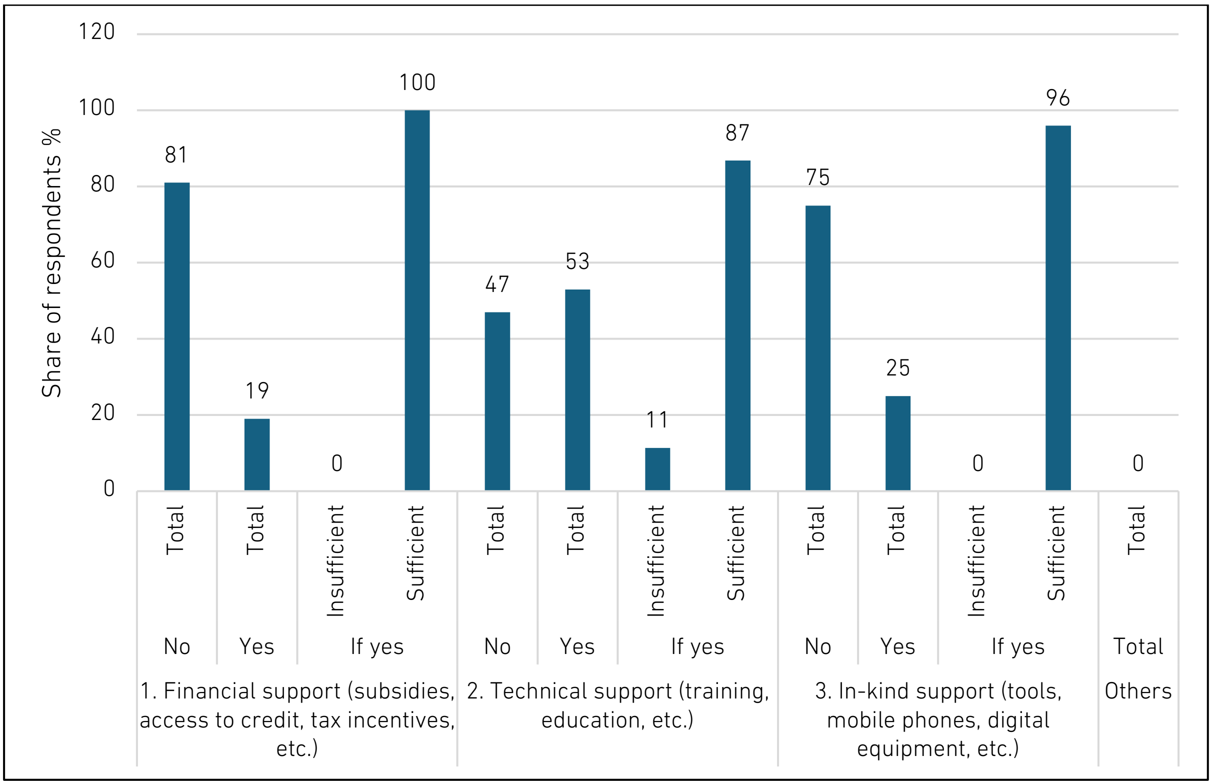
6.4.3 Government Initiatives to Support the Utilisation of Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain

6.4.3.1 Government Support for Using Digital Technologies and Introducing Digital Solutions

This survey investigated government initiatives to promote digital technologies in agriculture. These initiatives include financial, technical, and in-kind support.

Respondents reported that capacity building through technical support accounted for about 53% and was mainly promoted by development projects and non-governmental organisations (NGOs). The reported level of satisfaction with these initiatives was 87%. In addition, farmers received in-kind and financial support from the government, accounting for 25% and 19%, respectively.

Figure 6.12. Support Received from the Government for Using Digital Technologies



Source: Authors.

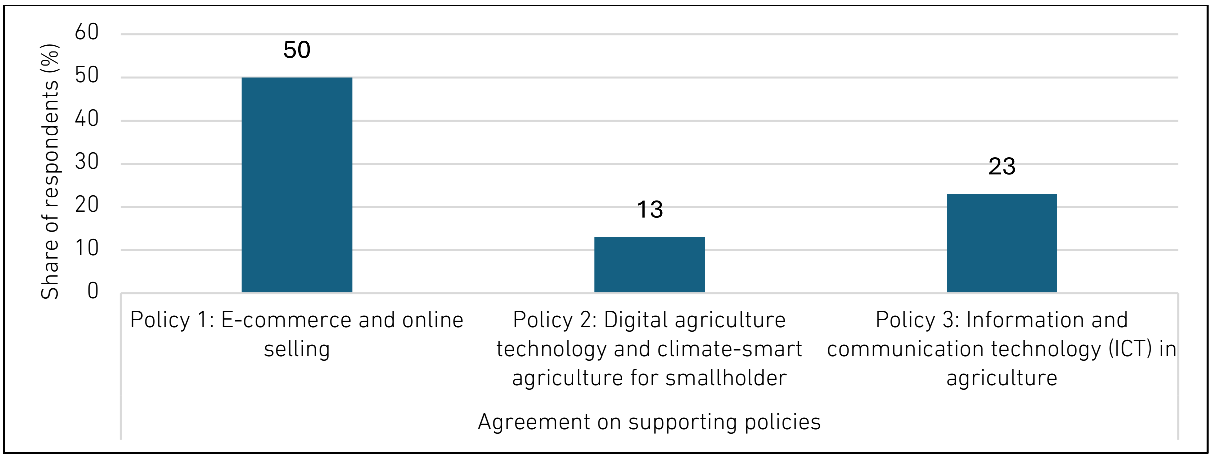
6.4.3.2 Policies, Programmes, and Initiatives to Utilise Digital Technologies and Introduce Digital Solutions

Recently, the Lao government has paid greater attention to promoting digital innovation and the application of digital technologies in the agricultural sector. In this assessment, three important policies were investigated: e-commerce and online selling (Policy 1), digital agriculture technology and climate-smart agriculture for smallholder farmers (Policy 2), and information and communication technology (ICT) in agriculture (Policy 3).

First, e-commerce and online selling were developed and promoted during COVID-19, enabling both food and non-food products to be ordered by mobile phone and delivered through services such as Food Panda and GoTeddy. In addition, Anousith and Houg-Aloun logistics companies helped traders and online sellers connect with consumers through online payment systems. The Lao government also allowed the operation of online trading platforms, such as AgriLao. Second, digitalisation and climate-smart agriculture aim to modernise agricultural production in Lao PDR through the automation of irrigation systems, solar pumps, precision agriculture, and drone applications. In addition to these digital technologies, the use of climate-resilient seed varieties also plays an important role. Third, policies on ICT in agriculture are promoted to help farmers access technical advice and services through internet platforms, providing information on pests and diseases, as well as weather conditions. The results showed that respondents agreed that policies on e-commerce and online selling are important for farmers, as they help improve market access and differ from traditional trading systems.

The survey results indicate that 50% of respondents were aware of policies on e-commerce and online selling, making it the most widely recognised policy. This was followed by policies on ICT in agriculture, which were recognised by 23% of respondents. Finally, digital agriculture and climate-smart agriculture for small farmers accounted for only 13%. Overall, farmers showed greater interest in digital technologies that facilitate product sales and speed up payments, whilst available agricultural platforms, such as LaoCSA, had limited access and were not widely known amongst farmers and extension workers.

Figure 6.13. Awareness of Policies for Utilising Digital Technologies

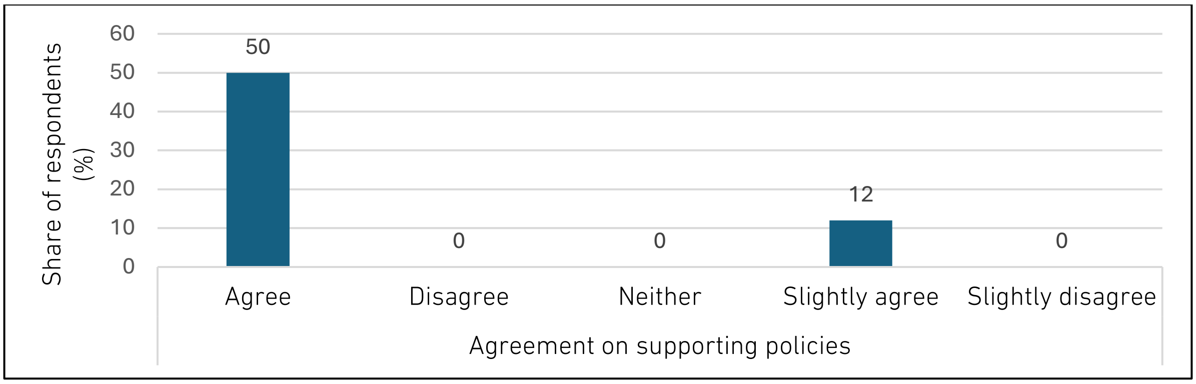


Source: Authors.

6.4.3.3 Agreement on Policies to Support Activities

Respondents reported moderate agreement with the policies that supported their activities. The results shown in Figure 6.14 indicate that 50% of respondents agreed, whilst 12% slightly agreed. Lao policies on agricultural digitalisation, promoting market access, and income generation were viewed as positive but require stronger enforcement in the near future.

Figure 6.14. Agreement on Supporting Policies



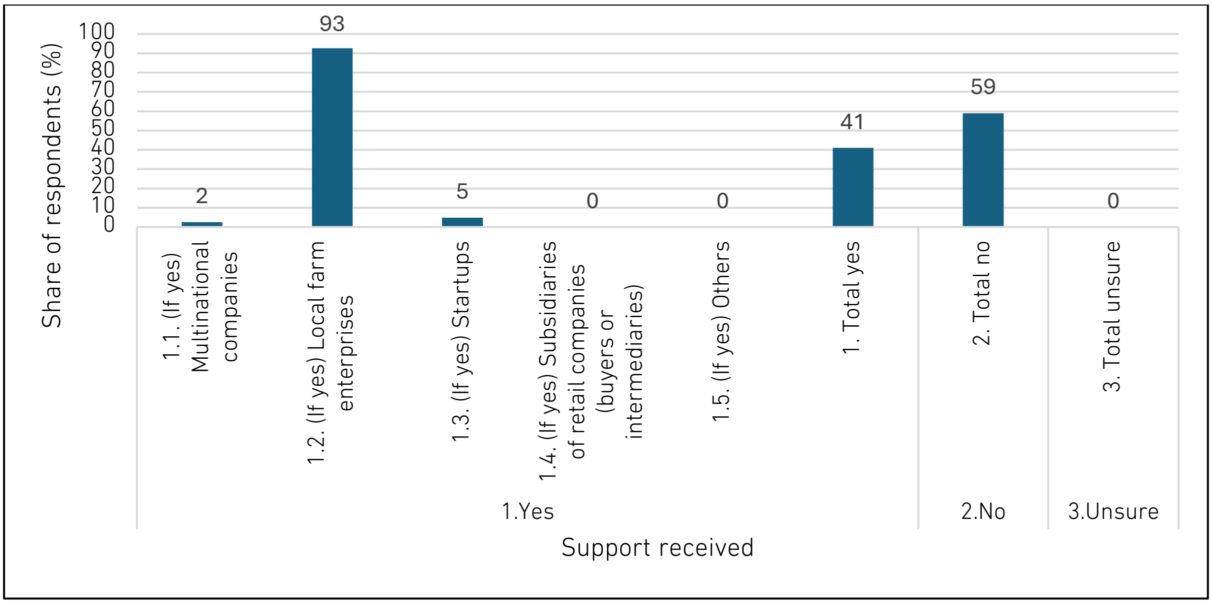
Source: Authors.

6.4.4 Private Sector Support for the Utilisation of Digital Technologies and Tools in Agriculture Production and Along the Food Value Chain

6.4.4.1 Support from the Private Sector for Utilising Digital Technologies and Introducing Digital Solutions

The private sector plays an important role in supporting smallholder farmers and businesses to apply modern technologies that aim to increase productivity and income, as well as reduce labour and post-harvest losses. The survey results (Figure 6.15) showed that only 40% of respondents received support for digital technologies from the private sector. The majority of support came from local farm enterprises, with only a small contribution from multinational companies and startups. This indicates a significant gap between the level of investment by international private companies in Lao PDR and their engagement in social responsibility initiatives.

Figure 6.15. Support Received from the Private Sector



Source: Authors.

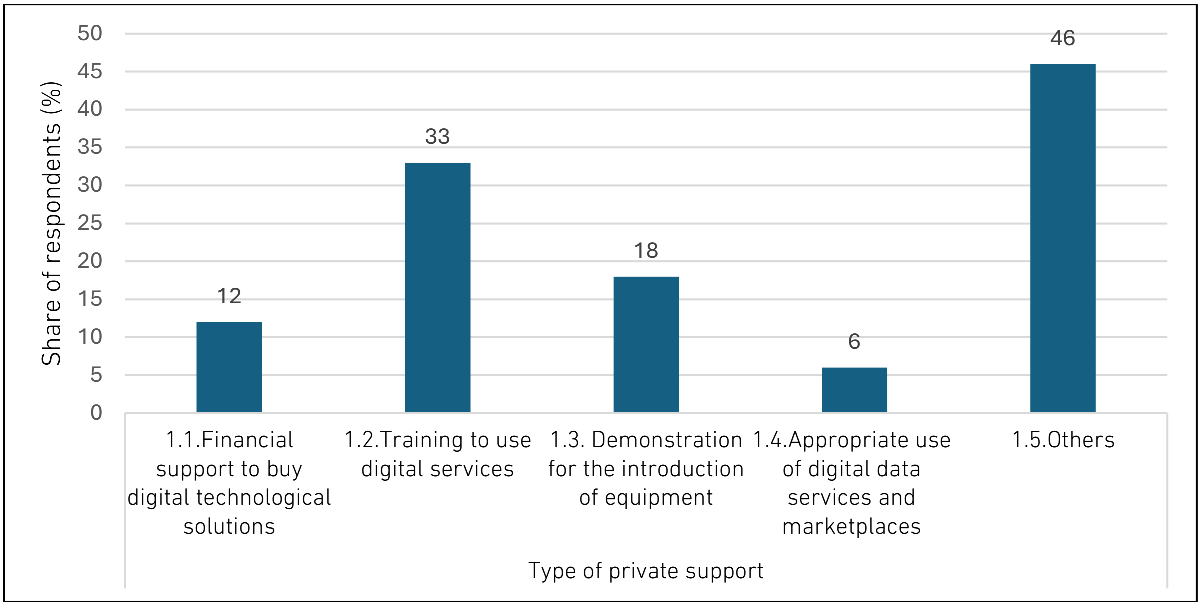
6.4.4.2 Type of Support from the Private Sector for Utilising Digital Technologies and Introducing Digital Solutions

The utilisation of digital technologies in agriculture could be accelerated through the promotion of private sector involvement. The results of the survey showed that the most common form of private support in Lao PDR was training on the use of digital services, which accounted for 33% of respondents' answers. The second most important form of private support was demonstration activities for introducing equipment. For example, development projects from the Republic of Korea and the World Bank, such as Harnessing Digital Agriculture Technologies for Smallholder Farmers, have been testing digital solutions to improve access to quality inputs and e-extension services.

Finally, financial support for purchasing digital technology solutions, as well as support for the appropriate use of digital data services and marketplaces, remains considerably low in Lao PDR.

Farmers often reported that they did not know where to sell their products, whilst traders and distributors claimed that they lacked sufficient local food, fruits, and vegetables and that these agricultural supplies were inconsistent throughout the year. This suggests that traceability and transparency across the agri-food supply chain, from production to consumption, need to be further developed.

Figure 6.16. Type of Support from the Private Sector for Utilising Digital Technologies



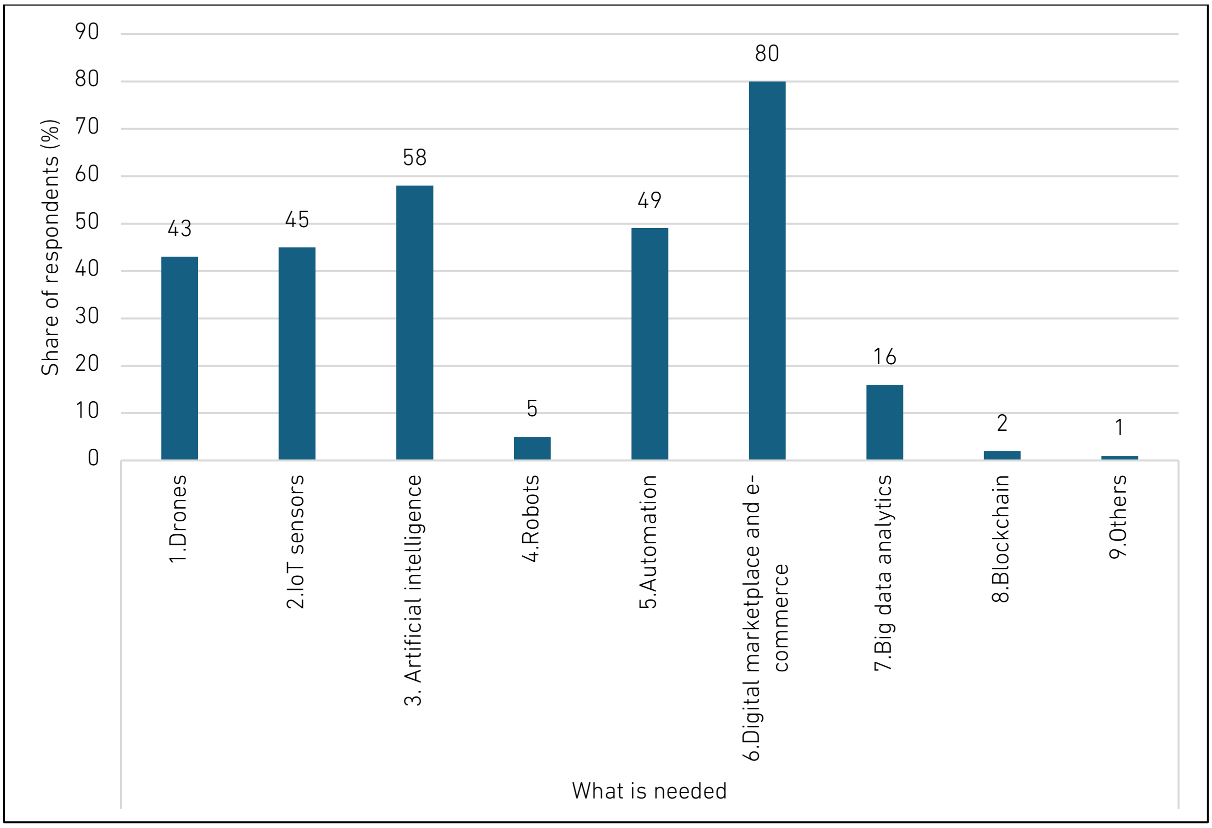
Source: Authors.

6.4.5 The Future of Digitalisation in Agriculture

6.4.5.1 Impact of Digital Technologies on the Future of Agriculture in ASEAN

Agriculture is an important sector not only in Lao PDR but also in ASEAN. Respondents identified priority areas for digital technologies in agriculture in Lao PDR. Five essential digital agriculture applications were identified: digital marketplaces and e-commerce, AI, automation, IoT sensors, and drones (Figure 6.17). Respondents, including the majority of farmers, reported that they currently use only QR codes for payments and information sharing. Challenges related to market access for Lao smallholders were frequently raised, and data availability on agricultural production, inputs, soil fertility, weather conditions, pests, and diseases are needed to be improved to enhance productivity. However, market information, such as on food demand and market prices, is not well linked or shared with agri-food producers and co-operatives. In addition, new innovative technologies and automation need to be introduced in ways that are accessible and affordable for farmers, as the current economic crisis and inflation in Lao PDR remain challenging, and young labour has migrated overseas. As a result, labour shortages are inevitable.

Figure 6.17. Future of Digital Applications



Source: Authors.

6.5 Recommendations

The main recommendations for the application and development of digitalisation in agriculture in Lao PDR are as follows.

6.5.1 Key Areas for Digital Application in Agriculture in Lao PDR

1. Digital Precision Agriculture

- IoT sensors and weather stations: Deploy low-cost IoT sensors for real-time monitoring of soil moisture, nutrient levels, and local microclimates. Integrate IoT sensors with digital application platforms to provide weather forecasts that enhance farmers' ability to make decisions on irrigation, fertilisation, and planting schedules.
- Drone technology: Utilising drones and GIS systems can promote efficient agricultural land management through mapping and monitoring crop health, including the early identification of pest and disease infections. Drone technology can improve the precision of applying inputs, such as fertilisers and pesticides, reduce waste, minimise environmental impacts, and reduce labour requirements for agrochemical application.

2. Enhance Market Access and Value Chain Promotion

- E-commerce platforms for farmers: Develop and promote online trading and mobile-based e-commerce platforms that help connect farmers and food producers directly with agricultural buyers or distributors (consumers, retailers, and agro-processors). Online trading can minimise intermediaries, increase farmers' income, and provide better traceability and market transparency.
- Traceability systems (blockchain): Introduce traceability systems (blockchain) or similar technologies to identify the origin of products and ensure tracking of agricultural products from farm to consumer. This practice can promote food safety, build consumer trust, and add value to Lao products in the market.

3. Digital Extension and Knowledge Transfer

- Mobile-based agricultural extension services: Develop interactive and real-time mobile applications or use existing messaging platforms (e.g. LaoCSA, WhatsApp, Facebook, and knowledge hubs) to provide agricultural advice, best practices, disease management tools, and climate-smart agriculture techniques, using media tools in the Lao language.
- Online learning modules and e-training: Create free and accessible online courses and e-learning materials on modern and climate-smart farming techniques, business management, and sustainable practices that can be accessed via smartphones.

4. Financial Incentives and Access to Inputs

- **Digital microfinance and mobile banking:** Expand access to digital financial services for farmers, including mobile payments for inputs, loans, and savings. This can reduce reliance on cash, improve financial security, and facilitate access to credit for investments.
- **Digital systems for inputs:** Implement digital demand and supply systems to enable farmers to access quality seeds, fertilisers, and other agricultural inputs. These systems can allow farmers to purchase inputs in bulk, reduce transportation costs, and ensure transparency for farmer groups and co-operatives.
- **Incentives for agri-tech startups for youth in agriculture:** Create an enabling environment for local and international agri-tech startups to develop and deploy innovative solutions in Lao PDR, including tax incentives, small financial schemes, matching grants, and soft loans.

6.5.2 Development Strategies

1. Capacity Building and Digital Literacy

- **Farmer and extension worker training programmes:** Implement comprehensive training programmes to enhance digital literacy amongst farmers and extension workers, enabling them to use smartphones, access digital platforms, and understand digital data.

2. Policy and Regulatory Framework

- **National digital agriculture strategy:** Develop a national digital agriculture strategy that clearly outlines goals, priorities, and investment areas. The Lao government should establish clear policies on data collection, ownership, privacy, and sharing in the agricultural sector to build trust and ensure effective data utilisation.

3. Partnerships and Collaboration

- **Public–private community partnerships:** Enhance collaboration amongst the government, private sector companies (telecommunications providers, agri-tech companies, and food enterprises), NGOs, and development partners to co-create and scale up digital agriculture solutions.
- **International co-operation, research, and development:** Promote exchange visits and learning from successful digital agriculture initiatives in ASEAN countries (e.g. Viet Nam, Thailand, and Indonesia) as well as from selected experiences in China and Japan that can be adapted in Lao PDR. Technical assistance and funding from international organisations can support local research and development to adapt digital technologies to the specific needs and challenges of Lao agriculture.

6.6 Conclusion

Lao PDR is increasingly recognising the potential of digital transformation in its agricultural sector, which is crucial for the country, where agriculture remains a significant contributor to GDP, employment, and rural livelihoods. This study highlights recommendations for a more digitally integrated future, although several challenges were also identified. Lao PDR has begun developing and applying agricultural digitalisation; however, progress has been constrained by limitations in digital infrastructure development and policy frameworks.

To achieve successful adoption, challenges related to affordability, digital literacy, and sustainable funding need to be addressed. By strengthening strategic partnerships, investing in human capital, and developing context-specific digital solutions, Lao PDR has the potential to transform its agricultural sector, achieve sustainable growth, and enhance competitiveness in regional and global markets.

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Chapter 7

Digitalisation in Malaysia's Agriculture and Food Systems for Enhancing Resilience and Improving Sustainability: Preliminary Assessment Study

Norsida binti Man

7.1 Introduction

Agriculture is one of the main sectors in Malaysia for generating national economic growth. This sector contributes through the production of paddy, food crops, rubber, and oil palm for export and domestic consumption. In addition, it helps supply raw materials and food, generate export income, and create employment opportunities. However, as one of the major sectors locally and globally, agriculture is encountering challenges in a rapidly changing world. Population growth, extreme weather, pests, soil fertility constraints, and market disruptions are straining agriculture and food systems at the global, regional, and local levels. A projected population of 723 million in the Association of Southeast Asian Nations (ASEAN) by 2030 is increasing pressure on food security, water resources, and agricultural labour. To address these challenges, the application of advanced digital technologies in agriculture is essential for future resilience and productivity. To remain competitive in an increasingly dynamic and volatile market, Malaysia must enhance its agricultural practices through the adoption of digitalisation in agriculture. The adoption of digital technology across diverse sectors is instrumental in fostering innovation, enhancing operational efficiency, and facilitating economic advancement. Digital tools are revolutionising industries by enabling novel products, services, and business models, as well as facilitating innovative modes of co-operation and production (Schaffers et al., 2022). The utilisation of digital technologies can facilitate the management of agricultural product quality through the incorporation of modern breeding and genetic advancements, allowing for personalised approaches to livestock and poultry care (Kolmykova et al., 2021).

Malaysia's agricultural sector therefore needs to be revitalised through the use of modern technologies, the production of high-quality and value-added products, the unlocking of potential in biotechnology, increased convergence with information and communication technology (ICT), and the participation of entrepreneurial farmers and a skilled workforce. To support the adoption of digital agriculture technologies, a government agency under the jurisdiction of the Ministry of Digital, the Malaysia Digital Economy Corporation, was established in 1996 to lead Malaysia's digital economy. As a result of its ongoing efforts to raise awareness of the benefits of adopting big data and analytics for precision agriculture and farm yields, many agricultural companies have embraced smart technologies. In addition, technology can help the country move towards a more advanced industry by generating economic benefits, including job opportunities and increased crop yields.

This study was conducted as a way to strengthen and support this initiative. The objectives of the study are to:

1) Assess the actual status of digital technology adoption in the agricultural value chain;
2) Identify challenges to the diffusion of digital technology adoption in agriculture and food systems; and
3) Identify and analyse instruments related to digitalisation policy.

7.2 Method

7.2.1 Data Collection Methods

Data collection process used an online survey through Google Forms and phone calls. The provided structured questionnaires were translated into the Malay language and adjusted to suit Malaysian farmers. Enumerators assisted farmers in answering the questionnaires, or respondents answered the questionnaires by themselves. A purposive sampling method was used to select the respondents.

7.2.2 Key Informants

To understand the current situation of digital technology usage, many key informants were involved in this study. These informants included agriculture Officers from the Department of Agriculture, fisheries officers from the Department of Fisheries, veterinary officers from the Department of Veterinary Services, marketing officers from the Federal Agriculture Marketing Authority, selected farmers, digital technology service providers, agricultural digital technologies companies and agricultural technology experts. These key informants supported researchers by providing lists and contact details of farmers, and enumerators subsequently contacted the respondents.

7.2.3 Respondent Selection

Target respondents were selected from several agricultural subsectors, including vegetable and fruit farming, livestock, fisheries and aquaculture, and paddy. The study location was limited to Peninsular Malaysia and did not include Sabah and Sarawak in East Malaysia. A total of 100 respondents were targeted for selection from each category; however, due to difficulties in achieving the exact target numbers, some categories had more respondents than others. Respondents were selected from amongst farmers and farm enterprises that use digital agriculture technologies. The farmer categories included individual farmers, Permanent Food Production Park farmers, aquaculture farmers, livestock farmers, and company farms (Table 7.1).

Table 7.1. Respondent Categories and Numbers

No.	Category of respondents	Number of targeted respondents
1	Vegetables and fruit	20
2	Fisheries/aquaculture	20
3	Livestock	20
4	Product marketing	20
5	Paddy	20
Total respondents		100

Source: Authors.

7.3 Data Analysis and Interpretation

7.3.1 Profile of Respondents

Descriptive analysis was used to investigate respondents' profiles. The demographic profile includes questions related to gender, age, race, marital status, education level, main occupation, monthly income, number of dependents, and years of experience in the agricultural field. The objective of this section is to provide a comprehensive picture of the socio-demographic background of the respondents, which is important for understanding their adoption of digital agricultural technologies.

7.3.1.1 Category of Respondents

Table 7.2 shows the distribution of respondents based on their roles in the agriculture sector. The majority of respondents, comprising 75 individuals, were farmers, whilst technology providers accounted for 8 respondents, reflecting the presence of stakeholders involved in the development and implementation of digital agriculture. Wholesalers (2 respondents), distributors (2 respondents), and processors (2 respondents) were also represented, suggesting their limited but relevant roles in the adoption of digital technologies. Consumers and co-operatives were each represented by 3 respondents. The 6 respondents classified as 'others' may represent individuals or organisations, including those involved in quality assurance and quality control, as well as managers and students. This distribution provides a more comprehensive assessment of digital adoption in the sector whilst emphasising the critical role of farmers as the primary adopters.

Table 7.2. Category of Respondents

Category of respondents	Frequency	Share (%)
Farmers	75	75
Wholesalers	2	2
Processors	1	1
Distributors	2	2
Co-operatives	3	3
Technology providers	8	8
Consumers	3	3
Others	6	6

Source: Authors.

7.3.1.2 Main Commodities

Table 7.3 presents the main commodities produced by respondents in this study, highlighting the diversity of agricultural and food production sectors involved. The largest group, comprising 54 respondents, was engaged in greenhouse fruit and/or vegetable production, indicating a growing trend towards controlled-environment agriculture. This was followed by rice cultivation, with 15 respondents, signifying its continued importance as a staple crop. Aquaculture accounted for 14 respondents, whilst traditional fruit and vegetable farming represented 8 respondents, and livestock and poultry farming included 5 respondents. Finally, the 4 respondents categorised as 'others' represented oil palm and ruminant livestock production.

Table 7.3. Main Commodities

Main commodity	Frequency	Share (%)
Rice	15	15
Fruit and/or vegetables (traditional)	8	8
Livestock and poultry	5	5
Aquaculture	14	14
Fruit and/or vegetables (greenhouse)	54	54
Others	4	4

Source: Authors.

7.3.1.3 Years of Experience

Table 7.4 shows the distribution of respondents based on their years of experience in the agricultural sector. Most respondents, comprising 50 individuals, had between 5 and 10 years of experience. Meanwhile, 28 respondents had less than 5 years of experience, indicating a significant presence of newcomers, which may reflect recent interest in the agricultural sector. In contrast, only 15 respondents had between 11 and 20 years of experience, whilst those with over 20 years of experience accounted for just 7 respondents. This trend suggests a lower representation of highly experienced individuals, which may imply generational shifts in agricultural practices or challenges related to long-term retention in the industry.

Table 7.4. Years of Experience

Years of experience	Frequency	Share (%)
<5 years	28	28
5–10 years	50	50
11–20 years	15	15
>20 years	7	7

Source: Authors.

7.3.1.4 Age of Respondents

Table 7.5 shows the distribution of respondents based on their age, highlighting the demographic profiles of individuals involved in agriculture. Most respondents were in the 30–39 age group, with 38 respondents, indicating that younger middle-aged individuals were the dominant group in this study. In addition, 29 respondents were aged 40–49 years, showing a strong presence of experienced farmers who may have already established their agricultural practices. Meanwhile, 16 respondents were aged 50–59 years, and only 3 respondents were in the 60–69 age group, reflecting a declining number of older farmers. Interestingly, 14 respondents were aged 20–29 years, suggesting a growing interest amongst younger individuals in agriculture, potentially influenced by digitalisation and modern farming techniques.

Table 7.5. Age of Respondents

Age	Frequency	Share (%)
20–29 years old	14	14
30–39 years old	38	38
40–49 years old	29	29
50–59 years old	16	16
60–69 years old	3	3

Source: Authors, 2025.

7.3.1.5 Farm Size

Table 7.6 shows the distribution of farm sizes amongst respondents, indicating that most farms are relatively small in scale. A total of 43 respondents owned farms of less than 1 hectare, whilst 36 respondents operated farms ranging from 2 to 10 hectares. This indicates that small-scale farming is dominant in the study area. In contrast, only 1 respondent operated a farm of 11–19 hectares, whilst 5 respondents managed farms of 20–29 hectares. Additionally, 3 respondents owned farms larger than 30 hectares. The 12 respondents classified under the 'others' category were likely technology providers, consumers, or managers who did not own farms. Understanding these variations in farm size is crucial for policymakers and agricultural extension services to tailor digital technology initiatives that address the needs of both small- and large-scale farmers.

Table 7.6. Farm Size

Farm size	Frequency	Share (%)
<1 hectare	43	43
2–10 hectares	36	36
11–19 hectares	1	1
20–29 hectares	5	5
>30 hectares	3	3
Others	12	12

Source: Authors.

7.3.1.6 Gender

Table 7.7 shows the gender distribution of respondents involved in the study. Most respondents were male, accounting for 82 respondents of the total sample, whilst only 18 respondents were female. This indicates that the agricultural sector is predominantly male-dominated, which is consistent with traditional farming demographics where men often assume primary roles in farm management.

Table 7.7. Gender

Gender	Frequency	Share (%)
Male	82	82
Female	18	18

Source: Authors.

7.3.1.7 Education

Table 7.8 shows the educational background of respondents in the study. The majority of respondents, numbering 64, had attained higher education qualifications, including diplomas, bachelor's, master's, or doctoral degrees. In addition, 33 respondents had completed secondary education, whilst a small group of 3 respondents had vocational education. None of the respondents had only primary education, indicating that formal education plays an important role in the agricultural workforce. The high proportion of respondents with higher education suggests that many individuals in the sector are well equipped to understand and utilise digital agricultural technologies. Their exposure to higher education may contribute to better decision-making and a greater willingness to adopt digital tools that improve farming efficiency and productivity.

Table 7.8. Education

Education level	Frequency	Share (%)
Primary	0	0
Secondary	33	33
Vocational	3	3
Higher education (diploma, bachelor's, master's, or doctorate)	64	64

Source: Authors.

7.3.2 Types of Technologies and Tools in Agricultural Production and Along the Food Value Chain

7.3.2.1 Types of Digital Technologies and Tools Used in Farming Activities Along the Food Value Chain

1) Production

Table 7.9 provides an overview of the digital technologies and tools utilised in farming production amongst the 100 respondents. The most widely used digital technology is Internet of Things (IoT) sensors, with 46 respondents indicating their use, highlighting the growing adoption of smart farming tools for monitoring and optimising agricultural activities. Automation, farming advisory applications, and drones followed, with 23, 33, and 34 respondents indicating their use, respectively. Robotics is currently adopted by only 2 respondents, as the use of robots in Malaysia is still not widespread. Other digital technologies include artificial intelligence (AI) (10 respondents), data management software (11 respondents), and geographic information systems (GIS) (7 respondents). The relatively low adoption of precision agriculture (7 respondents) and remote sensing (7 respondents) indicate potential gaps in digital literacy or limited access to these advanced tools. The 'others' category (6 respondents) represents the use of Redtone smart farming services, DIY Smart Socket (Tuya), and combined IP CCTV systems for monitoring purposes, as well as traditional fish farming. Overall, the findings reflect a shift towards digitalisation in agriculture.

Table 7.9. Digital Technologies and Tools Used in Farming (Production)

Digital technologies and tools	Frequency	Share (%)
Farming advisory apps (production, distribution, and consumption)	33	33
Drones (monitoring crop growth, spraying fertiliser and pesticides)	34	34
IoT sensors	46	46
Robotics	2	2
Automation	23	23
Remote sensing and geographic information systems	7	7
Artificial intelligence	10	10
Precision agriculture	7	7
Data management software	11	11
Others	6	6

Source: Authors.

2) Distribution, Marketing, and Financing

Table 7.10 shows the adoption of digital technologies in the distribution, marketing, and financing aspects of farming. The most widely used tool is the digital marketplace, with 53 respondents utilising it to purchase agricultural inputs and share farm product information. This indicates that farmers recognise the benefits of online platforms in expanding market access. Digital applications for financing and payments amongst suppliers and buyers are also widely used, with 39 respondents reporting their use. However, the adoption of digital payment systems with banks is relatively lower, at 22 respondents, which may be due to limited awareness, infrastructure challenges, or a preference for traditional banking methods. In addition, 6 respondents indicated that they do not use any digital tools for distribution, marketing, or financing, suggesting that some respondents still rely on conventional methods. Finally, the 'others' category includes 11 respondents using manual methods, camera detection and AI models, IoT-based system applications for fertiliser mixing, food cutting machines, sensor applications and IoT-based systems for plant fertilisation processes, pH monitoring of plant media, electric fences on farms, and seed processing machines.

Table 7.10. Digital Technologies and Tools Used in Farming (Distribution, Marketing, and Financing)

Digital technologies and tools	Frequency	Share (%)
Digital marketplace (purchasing agricultural inputs, sharing farm product information, etc.)	53	53
Digital apps for financing and payments amongst suppliers and buyers	39	39
Digital payment systems with banks	22	22
Not using	6	6
Others	11	11

Source: Authors.

3) Digital Traceability of Farm Commodities Within Domestic and International Markets

Table 7.11 highlights the adoption of digital traceability technologies in farming, which are crucial for ensuring transparency and quality control in domestic and international markets. The most widely used technology is the application of sensors and IoT-based systems for sorting farm produce, with 51 respondents utilising these tools. In addition, 22 respondents use inbuilt QR codes or barcodes to store and share product information, indicating a growing trend in the use of digital labelling for traceability purposes. Meanwhile, blockchain technology, which provides secure and immutable tracking of product and logistics information, shows lower adoption, with only 9 respondents reporting its use. However, 13 respondents reported not using any digital traceability tools, reflecting gaps in adoption that may be attributed to cost constraints. The 'others' category includes 15 respondents who reported using manual methods, camera detection and AI models, IoT-based system applications for fertiliser mixing, food cutting machines, sensor applications and IoT-based systems for plant fertilisation processes, pH monitoring of plant media, electric fences on farms, and seed processing machines. Overall, the data suggest that whilst digital traceability is gaining traction, further efforts in education, infrastructure development, and financial support may be necessary to encourage wider implementation.

Table 7.11. Digital Technologies and Tools Used in Farming (Digital Traceability)

Digital technologies and tools	Frequency	Share (%)
Application of sensors and IoT-based systems for sorting farm produce	51	51
Blockchain technologies to identify product and logistics information	9	9
Inbuilt QR codes/barcodes containing the product information	22	22
Not using	13	13

Digital technologies and tools	Frequency	Share (%)
Others	15	15

Source: Authors.

7.3.2.2 Needs Areas for Applying Digital Solutions in the Agriculture and Food Value Chain

Table 7.12 presents the roles of digital solutions across various aspects of the agriculture and food value chain. The highest adoption rates are observed in increasing agricultural production and productivity (74 respondents) and reducing production or operational costs (71 respondents), indicating that farmers prioritise efficiency and cost savings when utilising digital technologies. In addition, 68 respondents use digital tools to enhance the quality of farm produce, which is important for market competitiveness. Labour-saving technologies, such as automated irrigation, fertilisation, and feeding systems, are also widely adopted, with 57 respondents reporting their use, addressing concerns related to workforce shortages (46 respondents). These findings indicate that digitalisation in agriculture is mainly driven by the need to optimise resources and improve product quality. Around 45 respondents implement technologies to reduce post-harvest losses and food waste, ensuring better resource utilisation. However, only 22 respondents use digital tools to mitigate climate change impacts, such as floods and droughts, and an even smaller number, 28 respondents, focus on environmentally friendly agriculture, including the reduction of greenhouse gas emissions.

Table 7.12. Needs Areas for Applying Digital Solutions in the Agriculture and Food Value Chain

Digital solution	Frequency	Share (%)
Increasing agricultural production and productivity	74	74
Reducing production/operation costs	71	71
Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding	57	57
Dealing with labour shortages	46	46
Enhancing the quality of farm produce	68	68
Reducing post-harvest loss, and food loss and waste	45	45
Mitigating the impacts of climate change (floods, droughts, etc.)	22	22
More environmentally friendly agriculture, including the reduction of greenhouse gas emissions	28	28
Exploring new marketing opportunities	37	37

Digital solution	Frequency	Share (%)
Increasing food safety	32	32
Assuring consumers of the origin and quality of products	26	26
Data management: data collection, analysis, storage, transfer, and sharing	48	48
Applying for support, such as subsidies, insurance, in agriculture (e.g. e-government platforms)	29	29
Others	0	0

Source: Authors.

Moreover, digital technologies are being leveraged for marketing, food safety, and consumer assurance, with 37 respondents exploring new marketing opportunities through digital platforms and 32 respondents focusing on improving food safety. However, consumer trust-building measures, such as assuring the origin and quality of products (26 respondents), are less emphasised, indicating room for improvement in traceability and transparency. Data management, including data collection, analysis, storage, and sharing, is utilised by 48 respondents, highlighting the growing importance of information-driven decision-making in agriculture. Meanwhile, 29 respondents apply digital support systems, such as e-government platforms, for accessing subsidies and insurance.

7.3.2.3 Challenges, Constraints, and Obstacles to Using Digital Technologies and Introducing Digital Solutions

1) Basic Infrastructure (Accessibility and Affordability)

Table 7.13 highlights the challenges, constraints, and obstacles faced by farmers in adopting digital technologies, particularly those related to the accessibility and affordability of basic infrastructure. The most significant barrier identified is underdeveloped mechanisation, with 53 respondents indicating a lack of necessary equipment and tools. In addition, access to broadband internet remains a major issue, affecting 48 respondents. Climate-induced natural disasters, such as floods, droughts, and landslides, also pose considerable challenges, affecting 37 respondents by disrupting agricultural activities and reducing the effectiveness of digital adoption. Another key issue is the availability of uninterrupted electricity supply, which affects 35 respondents. Farm size also plays a role, with 29 respondents identifying land size as a constraint. Only 5 respondents reported other challenges, including difficulties in adapting IoT technologies to the local environment, rice crop failures due to weather conditions, and limited project viability resulting from market disruptions caused by excessive imports and a lack of capital.

Table 7.13. Challenges, Constraints, and Obstacles to Using Digital Technologies (Basic Infrastructure: Accessibility and Affordability)

Challenges, constraints, and obstacles	Frequency	Share (%)
Availability of uninterrupted electricity supply	35	35
Access to broadband internet	48	48
Farmers' land size	29	29
Climate-induced natural disasters, frequent floods, droughts, landslides, etc.	37	37
Underdeveloped mechanisation (lack of equipment and tools)	53	53
Others	5	5

Source: Authors.

2) Human Resources

Table 7.14 highlights human resource-related challenges in adopting digital technologies in agriculture. The most significant obstacle identified is the lack of digital skills or training at the farm level, affecting 68 respondents. This indicates that many farmers lack the necessary expertise to effectively implement and utilise digital solutions in their agricultural activities. In addition, limited digital literacy regarding available and potential digital technologies is a major constraint, reported by 65 respondents. Other constraints include a lack of digital skills or training along the agricultural value chain (45 respondents) and an insufficient number of extension workers or digital technology service providers with the required skills (40 respondents). Conservative attitudes, such as resistance to change, reported by 40 respondents, further complicate efforts to introduce new technologies. Finally, 4 respondents selected 'others', referring mainly to older farmers who find it difficult to adapt to new technological changes and systems.

Table 7.14. Challenges, Constraints, and Obstacles to Using Digital Technologies (Human Resources)

Challenges, constraints, and obstacles	Frequency	Share (%)
Digital literacy regarding available and potential digital technologies	65	65
Lack of extension workers and digital technology service providers with digital skills	40	40
Lack of digital skills or training at the farm level	68	68
Lack of digital skills or training along the value chain	45	45
Conservative attitudes, such as resistance to change	40	40
Others	4	4

Source: Authors.

3) Financial

Table 7.15 highlights financial constraints as a significant barrier to the adoption of digital technologies in agriculture. The most significant challenge, reported by 79 respondents, is the high cost associated with adopting new technologies, as many farmers face financial limitations that prevent them from investing in modern agricultural tools and digital solutions. In addition, 68 respondents identified the lack of financial incentives for infrastructure development and training programmes as a major constraint, indicating that government and institutional support remain insufficient for promoting digital adoption amongst farmers. Other financial challenges include limited public support for digital technology adoption (40 respondents) and restricted access to concessional loans and credit facilities (23 respondents). The 'others' category, reported by 2 respondents, refers to the lack of agronomists and vendors who understand the basic needs of agriculture in system development, as existing IoT systems are often adapted from foreign countries and may exceed the practical needs of agriculture in Malaysia. Overall, these findings suggest that farmers face difficulties in securing adequate funding and financial assistance to transition to digital agriculture.

Table 7.15. Challenges, Constraints, and Obstacles to Using Digital Technologies (Financial)

Challenges, constraints, and obstacles	Frequency	Share (%)
High cost of adopting new technologies	79	79
Lack of financial incentives for developing infrastructure and training programmes	68	68
Limited public support for the uptake of digital technology	40	40
Access to concessionary loans and credit	23	23
Others	2	2

Source: Authors.

4) Institutional

Table 7.16 highlights institutional barriers as key challenges in the adoption of digital technologies in agriculture. One of the major constraints is inconsistency in government strategies and frequent changes in farm policy, reported by 51 respondents. Additionally, 50 respondents identified the lack of intergovernmental co-ordination and organisational structure as a challenge, indicating the need for better alignment between government agencies, policymakers, and agricultural stakeholders to create a more cohesive strategy for digitalisation. Other barriers include limited policy instruments and framework conditions that support agriculture digitalisation (41 respondents) and the lack of co-ordinated operations amongst public–private and local stakeholders (50 respondents). Lastly, other challenges include farmers' lack of familiarity with the latest technologies and government. These findings suggest that existing policies and collaboration mechanisms are insufficient for facilitating smooth digital adoption.

Table 7.16. Challenges, Constraints, and Obstacles to Using Digital Technologies (Institutional)

Challenges, constraints, and obstacles	Frequency	Share (%)
Limited policy instruments and framework conditions that support agriculture digitalisation	41	41
Lack of intergovernmental co-ordination and/or organisational structure	50	50
Inconsistent governmental strategies and frequent changes in farm policy	51	51
Lack of co-ordinated operations amongst public–private and local stakeholders	50	50
Others	5	5

Source: Authors.

5) Digitalised Data Management and Information Transfer

Table 7.17 shows challenges related to digitalised data management and information transfer, which represent notable barriers to the effective use of digital technologies in agriculture. The most frequently reported issue is the limited availability of digitalised data and the high cost of digitalisation, cited by 62 respondents, indicating that affordability and access remain key concerns. In addition, 43 respondents reported the lack of publicly or privately provided data facilities, such as soil maps and market information, which limits farmers' ability to make informed, data-driven decisions. Difficulties related to software management, particularly the limited availability of systems in local languages for data integration and data sharing, were reported by 45 respondents, suggesting usability and compatibility challenges. Meanwhile, cybersecurity threats were identified by 29 respondents, reflecting growing concerns over data protection and system security. Overall, the findings indicate that challenges in data availability, system affordability, and user-friendly data management continue to constrain the wider adoption of digital technologies across the agricultural value chain.

Table 7.17. Challenges, Constraints, and Obstacles to Using Digital Technologies (Digitalised Data Management and Information Transfer)

Challenges, constraints, and obstacles	Frequency	Share (%)
Digitalised data availability and the cost of digitalisation	62	62
Lack of facilities for data provided by the public or private sector, such as soil maps and market information	43	43
Cybersecurity threats	29	29
Software management in local languages for data integration and data sharing	45	45
Others	3	3

Source: Authors.

7.3.3 Government Initiatives to Support the Utilisation of Digital Technologies and Tools in Agricultural Production and Along the Food Value Chain

7.3.3.1 Types of Support Received from the Government for Using Digital Technologies and Introducing Digital Solutions

1) Financial Support (Subsidies, Access to Credit, Tax Incentives, etc.)

The data in Table 7.18 present insights into government financial support for the adoption of digital technologies in agriculture. Amongst the respondents, only 24 indicated that they received sufficient financial support in the form of subsidies, access to credit, or tax incentives. Meanwhile, 41 respondents stated that they had received financial assistance, but that it was insufficient to fully support the digitalisation process. Furthermore, 35 respondents reported receiving no financial support from the government. This highlights a gap in access to funding opportunities, which may hinder the widespread adoption of digital tools in agriculture. The findings indicate a need for more structured and comprehensive financial assistance programmes to ensure that farmers, especially those with limited resources, can successfully transition to digital agriculture.

Table 7.18. Receipt of Government Support (Financial)

Government support	Frequency	Share (%)
Yes, sufficient	24	24
Yes, insufficient	41	41
No	35	35

Source: Authors.

2) Technical Support (Training, Education, etc.)

Table 7.19 shows the extent of government support in terms of technical assistance, such as training and education, for the adoption of digital technologies in agriculture. The findings reveal that only 22 respondents reported receiving sufficient technical support, indicating that government-led initiatives in this area are still limited. Meanwhile, 41 respondents acknowledged that they had received some form of training or education, but that it was insufficient to fully equip them with the necessary skills and knowledge to implement digital solutions effectively. Additionally, 37 respondents stated that they had received no technical support at all. This highlights a significant gap in knowledge transfer and skill development, which could hinder the adoption of digital technologies in the agricultural sector. Without adequate training and education, farmers may struggle to utilise digital tools efficiently, reducing their potential benefits.

Table 7.19. Receipt of Government Support (Technical)

Government support	Frequency	Share (%)
Yes, sufficient	22	22
Yes, insufficient	41	41
No	37	37

Source: Authors.

3) In-kind Support (Tools, Mobile Phones, Digital Equipment, etc.)

Table 7.20 highlights the level of government support in the form of in-kind assistance, such as tools, mobile phones, and other digital equipment, to facilitate digital adoption in agriculture. The findings indicate that only 20 respondents received sufficient in-kind support, suggesting that only a small portion of farmers have access to essential digital tools through government initiatives. Meanwhile, 32 respondents reported receiving some level of in-kind support, but it was deemed insufficient to fully meet their needs. Furthermore, nearly half of the respondents (48 respondents) stated that they had not received any form of in-kind support. This significant percentage reflects a major gap in resource allocation, which could hinder the adoption of digital technologies in agricultural practices. Without access to essential tools and digital equipment, farmers may face challenges in integrating technology into their daily operations, limiting their productivity and efficiency.

Table 7.20. Receipt of Government Support (In-kind)

Government support	Frequency	Share (%)
Yes, sufficient	20	20
Yes, insufficient	32	32
No	48	48

Source: Authors.

7.3.4 Policies, Programmes, and Initiatives That Aim to Utilise Digital Technologies and Introduce Digital Solutions

7.3.4.1 Policies That Utilise Digital Technologies and Introduce Digital Solutions

The data in Table 7.21 show the awareness of policies that aim to utilise digital technologies and introduce digital solutions in the agricultural sector. Amongst the respondents, 41 respondents recognised the 'Fourth Industrial Revolution (IR4.0) Malaysia' policy, which signifies a growing awareness of the importance of industrial digitalisation in agriculture. Additionally, 50 respondents were aware of the 'MyDigital' initiative, which reflects the government's effort to promote the digital economy and smart agriculture adoption. The highest level of awareness was recorded for the 'National Agrofood Policy' (NAP), with 52 respondents acknowledging its role in promoting digitalisation in the agriculture and food systems sector. This indicates that NAP is relatively well-known amongst farmers, likely due to its direct impact on agricultural sustainability and food security.

Table 7.21. Awareness of Policies That Utilise Digital Technologies and Introduce Digital Solutions

Policy	Frequency	Share (%)
Fourth Industrial Revolution (IR4.0) Malaysia	41	41
MyDigital	50	50
National Agrofood Policy (NAP)	52	52

Source: Authors, 2025.

7.3.4.2 Policies Supporting Digital Agriculture Activities

Table 7.22 shows respondents' perceptions of how supportive government policies are in facilitating agricultural activities through digitalisation. A majority of respondents (57) agreed that these policies are beneficial, whilst 33 slightly agreed, indicating that 90% of respondents recognise some level of policy support. This suggests that government initiatives, such as IR4.0 Malaysia, MyDigital, and NAP, have had a positive impact on the adoption of digital technologies in agriculture. However, 9 respondents remained neutral, whilst 1 slightly disagreed, possibly because they have not yet fully experienced or understood the benefits of these policies.

Table 7.22. Agreement with Supportive Policies

Level of agreement	Frequency	Share (%)
Agree	57	57
Slightly agree	33	33
Neither	9	9
Slightly disagree	1	1
Disagree	0	0

Source: Authors.

7.3.5 Private Sector Support for the Utilisation of Digital Technologies and Tools in Agricultural Production and Along the Food Value Chain

Table 7.23 highlights the level of support received from the private sector for utilising digital technologies in agriculture. A majority of respondents, 51, indicated that they had not received any support, whilst only 41 respondents acknowledged receiving assistance from private entities. Additionally, 8 respondents were unsure whether they had received support. These findings suggest that private sector involvement in promoting digital solutions within the agricultural sector is still limited. The high percentage of respondents reporting a lack of support indicates the need for stronger collaboration between private companies and farmers.

Table 7.23. Support from the Private Sector

Private sector support	Frequency	Share (%)
Yes	41	41
No	51	51
Unsure	8	8

Source: Authors.

7.3.5.1 Support from the Private Sector for Utilising Digital Technologies and Introducing Digital Solutions

Table 7.24 shows that the most common form of support was demonstrations for the introduction of equipment, reported by 29 respondents, indicating that private sector involvement is primarily focused on showcasing new technologies. Training on the use of digital services was the second most commonly reported type of support (19 respondents), followed by support for the appropriate use of digital data services and marketplaces (15 respondents). In contrast, financial support to purchase digital technological solutions was received by only 9 respondents. In addition, 7 respondents reported receiving other forms of support, mainly advisory services.

Table 7.24. Type of Support Received

Type of support	Frequency	Share (%)
Financial support for purchasing digital technological solutions	9	9
Training on the use of digital services	19	19
Demonstrations for the introduction of equipment	29	29
Appropriate use of digital data services and marketplaces	15	15
Others	7	7

Source: Authors.

7.3.6 The Future of Digitalisation in Agriculture

7.3.6.1 Digital Technologies with the Biggest Impact on the Medium- to Long-term Future of Agriculture in Malaysia

Table 7.25 shows respondents' perspectives on the digital technologies that will have the most significant impact on the future of agriculture in ASEAN. The highest-ranked technologies are AI, selected by 52 respondents, and IoT sensors and digital marketplaces, selected by 50 respondents each. This highlights the role of predictive analytics, real-time data collection, and online trading platforms in improving agricultural efficiency and market accessibility. In addition, drones, which are widely used for crop monitoring and the application of fertilisers, were recognised by 46 respondents, whilst automation technologies were identified by 40 respondents.

Moreover, 34 respondents highlighted big data analytics as a crucial technology, emphasising the importance of data-driven decision-making in farm management. Robotics, identified by 26 respondents, further indicates increasing recognition of automation. Blockchain, with only 19 respondents, was the least recognised technology. Notably, no respondents selected 'others', indicating a clear consensus on the key technologies shaping the future of digital agriculture. Overall, these findings underscore the importance of investing in IoT, AI, and automation to drive the digital transformation of agriculture in the ASEAN region.

Table 7.25. Types of Digital Agriculture Technology That Have the Biggest Impact on the Future

Type of digital technology	Frequency	Share (%)
Drones	46	46
IoT sensors	50	50
Artificial intelligence	52	52
Robots	26	26
Automation	40	40
Digital marketplace and e-commerce	50	50
Big data analytics	34	34
Blockchain	19	19
Others	0	0

Source: Authors.

7.4 Overview of Policies, Government Initiatives, and Programmes for Promoting the Utilisation of Digital Technologies in Agriculture and Food Systems

The three main policies, government initiatives, and programmes for promoting the utilisation of digital technologies in agriculture and food systems covered in this study are as follows.

1) Digital Focus in the National Agrofood Policy (NAP) 2021–2030

The main focus of this policy is to use smart and digital technologies to increase food production and ensure that the country's food supply is sufficient. In addition, the use of digital supply chain technologies, such as blockchain, aims to ensure a more transparent and efficient food supply chain from the farm to the consumer's table.

2) Malaysia's Fourth Industrial Revolution (IR4.0)

This initiative was introduced by the government to bring about major changes in economic sectors, including agriculture, through the use of advanced technology. IR4.0 involves the use of automation and digital technologies such as robotics, AI, IoT, and big data analytics to increase productivity and efficiency.

3) MyDigital

This major plan was introduced by the Malaysian government to accelerate the country's transformation towards a digital economy. MyDigital is the Malaysian Digital Economy Blueprint, which is designed to ensure that digital technology is widely used in daily life, employment, and business, including the agricultural sector.

There are many initiatives, focus areas, and policies that support the implementation of digital technologies in agriculture, such as the National Internet of Things (IoT) Framework, the Malaysia E-Agriculture Action Plan (2019–2025), the Cyber Security Policy, the E-Participation Policy, the National Green Technology Policy (2017–2030), and the Personal

Data Protection Policy. The effectiveness of each policy in driving changes towards the digitalisation of agriculture is still under study. Despite this, the adoption rate of digital agriculture technologies continues to increase due to the benefits introduced.

7.5 Way Forward

The study underscores the need for targeted policies to promote digital adoption amongst farmers. These policies should focus on increasing digital literacy through training programmes, expanding access to government subsidies, and strengthening agricultural extension services. Furthermore, collaboration between the government, the private sector, and research institutions can facilitate the development and dissemination of user-friendly agricultural technologies tailored to farmers' needs. Agricultural extension services serve as an essential bridge between farmers and technology by providing training, technical support, and knowledge dissemination. Enhancing the reach and quality of agricultural extension services can significantly improve farmers' confidence and ability to utilise digital technology effectively.

7.6 Conclusion

The adoption of digital technology in agriculture has become an essential factor in improving productivity, efficiency, and sustainability in the sector. This study investigates the adoption of agricultural digital technology amongst farmers and agriculture stakeholders in Peninsular Malaysia. The research examines several primary factors, especially socio-economic factors, types of digital technologies, challenges in adoption, government policies and initiatives, private involvement, and the future of digitalisation in promoting agriculture digital technologies. These factors play a crucial role in determining farmers' adoption of modern digital tools, which can significantly affect agricultural output and economic viability.

Digital literacy and government support are the most significant factors influencing farmers' adoption of agricultural digital technology. Farmers who possess higher levels of digital literacy are more likely to perceive the benefits of technology, understand how to use digital tools effectively, and integrate them into their farming practices. Moreover, government grants and subsidies play a vital role in reducing financial barriers to technology adoption, enabling farmers to invest in modern equipment such as precision farming tools, automated irrigation systems, and farm management software. Socio-economic factors, including age, education level, and income, also influence the adoption process. Younger farmers and those with higher education levels demonstrate a greater adoption of digital technology compared to older farmers, who may face challenges in learning new digital skills. Additionally, farmers with higher incomes are more inclined to invest in digital tools, whereas those facing financial constraints rely heavily on government assistance to access these technologies.

In conclusion, the findings of this study contribute valuable insights into the factors influencing digital technology adoption in the agricultural sector. By addressing the barriers to adoption and enhancing support mechanisms, policymakers and stakeholders can accelerate the digital transformation of agriculture in Malaysia, ultimately improving productivity, sustainability, and farmers' livelihoods.

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Chapter 8

Towards Resilience and Sustainability: Bridging the Divide Between the Promise and Reality of Digitalisation in Philippine Agriculture and Food Systems

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8.1 Overview and Background

The Philippine government's plan to future-proof the nation's development places a strong emphasis on digitalisation. According to the Philippine Development Plan 2023–2028, the nation aims to close the 'digital divide', whereby about 40% of people still do not have dependable internet access, in order to create a strong and globally competitive digital economy. The Philippines, an archipelago of more than 7,000 islands, has many obstacles when it comes to digitalisation, especially in terms of guaranteeing connectivity and obtaining the required funding for communication infrastructure. The Marcos administration acknowledged these difficulties by approving the US$280 million Philippine Digital Infrastructure Project in 2024, which aims to increase broadband availability across the country.

According to projections, the gross merchandise value of the Philippine digital economy could increase from US$35.4 billion in 2023 to US$150 billion by 2030, reflecting strong projected growth in the sector. The country's gross domestic product would increase by about 8.4% as a result of this growth. The industries that embraced digitalisation the earliest were e-commerce, retail, healthcare, finance, and the information technology and business process outsourcing sector. More recently, the COVID-19 pandemic, better internet connectivity, and the rise of new digital platforms have prompted the growth of industries like food and beverage and logistics.

As the government's long-standing objective of modernising Philippine agriculture gains fresh impetus through digitalisation, the agriculture sector is also catching up. Digital tools, from smartphone-based advisory services to farm management systems driven by artificial intelligence (AI), hold the potential to improve efficiency, strengthen climate resilience, and expand market access for farmers and fishers, as highlighted in *Transforming Philippine Agri-Food Systems with Digital Technology: Extent, Prospects, and Inclusiveness* (Briones et al, 2023). Whilst most of the sector still relies on manual, small-scale production, government agencies, private organisations, and research institutions are making greater efforts to harness digital innovations for the next phase of agricultural development in the country.

8.2 Methodology

The study collected responses from Philippine agricultural stakeholders using a structured questionnaire that was standardised for ASEAN country studies. It began with a review of the literature on current digital projects in the country's agriculture industry to create the sampling framework. As of 2024, about 10.66 million people work in agriculture, including 2.6 million rice farmers. Nevertheless, there is no complete database containing the names, addresses, or other details of farmers who use the internet.

To overcome this limitation, the research team started by conducting key informant interviews with key players from the crop, livestock, and fisheries industries, as well as the Department of Agriculture, specifically the head of its Information and Communication Technology Department. After that, the study used snowball sampling, starting with key informant interview leads. Together with the International Rice Research Institute, the Information and Communication Technology Department unit recognised the Philippine Rice Research Institute and the Agricultural Training Institute as important partners that actively interact with farmers. Representatives from the private sector also referred relevant stakeholders.

Respondents were chosen from the three main agricultural commodity groups, namely crops, poultry/livestock, and fisheries, and were interviewed both in person and online. Major rice, vegetable, poultry, livestock, and fisheries production areas in Luzon were the focus of in-person interviews. The online component covered the nation's three main island groups: Mindanao, Visayas, and Luzon. Institutions were unable to exchange lists of co-operative farmer-stakeholders due to limitations imposed by the Data Privacy Act. Instead, they invited target respondents to fill out and submit the forms online by sending e-copies of the questionnaire to their networks. Despite efforts to include respondents from all regions, the Visayas continued to have a low participation rate.

8.3 Interpretation and Analysis of the Data

8.3.1 Profile of the Philippine Agricultural Stakeholder in the Digital Age

It is essential to first create a thorough profile of the stakeholders involved in order to comprehend the dynamics of digital adoption. In order to create a comprehensive picture of the human capital, operational context, and geographic distribution of actors involved in or targeted by agricultural digitalisation, the analysis that follows goes beyond basic demographics. This profile serves as a critical starting point for interpreting all subsequent research on technology adoption, needs, and challenges.

8.3.1.1 Geographic and Sectoral Distribution: Mapping the Digitalisation Landscape

The geographic and sectoral composition of the survey participants offers a map of the current focus areas of digitalisation initiatives, as well as the perspectives of the most represented actors. The information shows a primary producer-dominated landscape that is concentrated in important production zones.

Table 8.1. Geographic Distribution of the Survey Respondents

Surveyed provinces	Share (%)
Cavite	3.26
Laguna	18.48
Batangas	18.48
Rizal	2.17
Quezon	14.13
Nueva Ecija	16.30
Visayas	6.52
Mindanao	20.65

Source: Authors.

With more than 73% of respondents coming from the provinces of Cavite, Laguna, Batangas, Rizal, Quezon, and Nueva Ecija combined, Table 8.1 demonstrates the survey's strong geographic focus on the island of Luzon. This concentration reflects the deliberate sampling of the nation's main rice and high-value crop production regions, especially the CALABARZON region and the 'rice granary' province of Nueva Ecija. Mindanao, a vital agricultural centre in the southern Philippines, is also well represented, at 20.65%. However, the data also reveal a major gap: at only 6.52%, the Visayas region, an entire island group with its own distinct agro-ecological conditions and logistical difficulties, is woefully underrepresented. This geographic imbalance is a significant study limitation, raising the possibility that the results do not accurately reflect the unique digitalisation requirements and obstacles that exist in the central Philippines.

Table 8.2. Classification of Survey Respondents (%)

Stakeholder	Rice	Fruits and/or vegetables (traditional)	Livestock and poultry	Aquaculture	Fruits and/or vegetables (greenhouse)	Other	All
Farmers	51.47	23.53	14.71	0.00	2.94	7.35	**70.1**
Wholesalers	50.00	0.00	50.00	0.00	0.00	0.00	**2.06**
Processors	0.00	0.00	50.00	0.00	0.00	50.00	**4.12**
Distributors	0.00	100.00	0.00	0.00	0.00	0.00	**1.03**
Co-operatives	75.00	0.00	25.00	0.00	0.00	0.00	**4.12**

Technology providers	33.33	33.33	8.33	0.00	8.33	16.67	**12.37**
Others	33.33	-	16.67	33.33	0.00	16.67	**6.19**
All	**46.39**	**21.65**	**16.49**	**2.06**	**3.09**	**10.31**	**100.00**

Source: Authors.

Perhaps the most revealing aspect of the survey sample is the sectoral distribution of respondents, which is shown in Table 8.2. Farmers make up the majority, accounting for 70.10% of all participants. Conversely, the representation of other important players along the value chain is significantly lower: distributors make up just 1.03%, wholesalers make up 2.06%, and processors and co-operatives each make up 4.12%. This composition suggests a 'production-centric bias' in the way agricultural digitalisation is currently discussed and studied. Although the focus on farmers is crucial, the study's findings will unavoidably reflect the perspective of primary production more strongly than that of downstream activities such as processing, logistics, and wholesale. As a result, the overall analysis may underrepresent the particular difficulties and technological requirements of these midstream and downstream actors, who are essential to a fully operational digital value chain.

8.3.1.2 Human Capital: Experience, Education, and Gender Dynamics

The traits of those working in the agriculture industry are amongst the main factors influencing digital readiness and adoption behaviour. According to the survey results, the stakeholder base is primarily male, experienced, and surprisingly well educated, defying popular assumptions and pointing to more complex obstacles to digitalisation.

Table 8.3. Gender Composition of the Survey Sample

Gender	Share (%)
Male	66.00
Female	34.00

Source: Authors.

There is a notable disparity in the respondents' gender distribution, with 34% of the sample being female and 66% male (Table 8.3). This discrepancy raises the possibility that existing digitalisation networks and initiatives are not reaching or involving female stakeholders to the same extent as their male counterparts. Because women are essential to many facets of agriculture, such as farm management, post-harvest processing, and marketing, this disparity has significant ramifications for ensuring that the advantages of digital transformation are shared fairly.

Table 8.4. Classification of Educational Level by Stakeholder Type (%)

Stakeholder	Elementary	Secondary/ high school	Vocational	Higher (diploma, bachelor's, master's, doctorate)
Farmers	1.01	6.06	7.07	50.51
Wholesaler	0.00	1.01	0.00	1.01
Processors	0.00	0.00	0.00	7.07
Distributors	0.00	0.00	0.00	1.01
Co-operatives	0.00	1.01	0.00	3.03
Technology providers	0.00	1.01	0.00	9.09
Others	0.00	1.01	0.00	4.04
Blanks	0.00	1.01	0.00	5.05
All	**1.01**	**11.11**	**7.07**	**80.81**

Source: Authors.

The respondents' high level of formal education is one of the most striking findings. An overwhelming 80.81% of all stakeholders have a higher education degree (diploma, bachelor's, master's, or doctorate), as shown in Table 8.4. The widespread perception of farmers as having low educational attainment is directly refuted by this trend, which even applies to farmers, where 50.51% have completed higher education. Given the high level of education amongst the sample, it is unlikely that a lack of basic knowledge or cognitive ability is the primary cause of barriers to technology adoption.

Table 8.5. Classification of Experience Level by Stakeholder Type (%)

Stakeholder	<5 years	5–10 years	11–20 years	>20 years
Farmers	19.35	32.26	12.9	35.48
Wholesalers	0.00	33.33	66.67	0.00
Business owners	0.00	25.00	25.00	50.00
Distributors	0.00	0.00	0.00	100.00
Co-operatives	0.00	33.33	0.00	66.67
Technology provider	40.00	20.00	30.00	10.00
Consumers	22.22	11.11	33.33	33.33
All	**18.75**	**28.13**	**16.67**	**36.46**

Source: Authors.

This knowledgeable stakeholder base also has extensive experience. According to Table 8.5, 36.46% of all respondents have worked in the field for more than 20 years. This depth of experience is especially noticeable amongst important value chain participants such as distributors, 100% of whom have more than 20 years of experience, co-operatives (66.67%), and business owners (50%). A sizable share of farmers (35.48%) are also seasoned veterans with more than 20 years of experience.

A crucial paradox arises when extensive experience and advanced education are combined. It disproves the oversimplified theory that resistance to technology is simply the result of ignorance or lack of education. When highly educated and experienced people decide not to use a certain technology, it is not a decision based on ignorance. Instead, it is likely to be a deliberate decision based on a thorough, if informal, cost-benefit analysis. Decades of real-world experience and an acute understanding of what functions well and poorly in their particular operational environment have influenced this analysis. This reframes the 'digital literacy' problem as one that involves more than just teaching skills; it also involves establishing credibility and proving tangible value to a knowledgeable and discerning audience.

Table 8.6. Classification of Experience by Main Product (%)

Main product	<5 years	5–10 years	11–20 years	>20 years
Rice	8.89	31.11	15.56	44.44
Fruits and/or vegetables (traditional)	45.00	30.00	5.00	20.00
Livestock and poultry	13.33	20.00	20.00	46.67
Aquaculture	33.33	0.00	0.00	66.67
Fruits and/or vegetables (greenhouse)	33.33	33.33	33.33	0.00
Others	11.11	33.33	33.33	22.22

Source: Authors.

Additionally, as Table 8.6 illustrates, experience levels differ considerably by commodity. Highly experienced people with more than 20 years of experience predominate in the more established and traditional subsectors, such as livestock and poultry (46.67%) and rice (44.44%). On the other hand, 45.00% of producers of traditional fruits and vegetables have less than 5 years of experience, making them far more likely to be recent entrants. This implies that different subsectors may be at varying stages of their life cycles and may require customised strategies for technology promotion and digital extension.

8.3.1.3 Operational Scale: A Focus on Rice Farming

The economic feasibility of many digital technologies, especially those requiring large capital investment, is significantly influenced by the operational scale of farming. A one-size-fits-all digital strategy is made more difficult by the fragmented landscape depicted by the data for rice farming, a vital component of Philippine agriculture.

Table 8.7. Classification of Farmers Participating in Rice Products by Scale

Farm size (hectares)	Share (%)
<0.5	15.15
0.5–3	31.31
>3	41.41
N/A	12.12

Source: Authors.

The distribution of rice farm sizes amongst survey respondents is clearly bimodal, as shown in Table 8.7. Some 41.41% of the cohort works on farms larger than 3 hectares. However, a total of 46.46% of farmers work smaller plots, ranging from less than 0.5 hectares to 3 hectares. This structural divide has significant implications for technology adoption of technology. Capital-intensive precision agriculture technologies, such as GPS-guided tractors, drones for spraying, or vast sensor networks, may be financially viable and provide alluring returns on investment for the 41% of farmers with larger landholdings. However, the high fixed costs of such technologies are probably too expensive for the nearly half of farmers who work on a smaller scale. This suggests that the rice industry will not benefit from a single digital strategy. A two-pronged strategy is required: one that advocates for sophisticated, capital-intensive solutions for larger commercial farms, and another that concentrates on affordable, scalable solutions for the vast majority of smallholders, like digital financial tools, mobile advisory services, and e-commerce platform access.

8.3.2 Current Landscape of Agricultural Digitalisation

This section offers a detailed, fact-based evaluation of the digital technologies currently in use, along with information on who is using them and why. A clear hierarchy of technology adoption and notable differences throughout the value chain are revealed by the analysis, which breaks down the ‘what’ and ‘who’ of adoption. This lays the groundwork for comprehending the fundamental forces and obstacles covered in the sections that follow.

8.3.2.1 Adoption of Production-oriented Technologies: From Advisory Apps to AI

There is a wide range in the adoption of digital tools used directly in agricultural production, with low-cost, information-based tools being strongly preferred over solutions that require more hardware or data.

Table 8.8. Rate of Application of Digital Technologies and Digital Tools in Agricultural Production by Actor (%)

Technology	Farmers	Wholesaler	Processors	Distributors	Co-operatives	Technology providers	Others	Blank	All
Farming advisory apps	59.38	50.00	28.57	100.00	50.00	63.64	0.00	50.00	**36.49**
Drones	9.38	0.00	14.29	100.00	25.00	36.36	0.00	0.00	**8.78**
IoT sensors	6.25	0.00	0.00	0.00	0.00	36.36	0.00	0.00	**5.41**
Robotics	1.56	0.00	0.00	0.00	0.00	0.00	0.00	16.67	**1.35**
Automation	9.38	0.00	57.14	100.00	0.00	18.18	0.00	16.67	**9.46**
Remote sensing and GIS	6.25	0.00	14.29	0.00	25.00	36.36	0.00	0.00	**6.76**
Artificial intelligence	4.69	100.00	14.29	0.00	0.00	36.36	20.00	0.00	**7.43**
Precision agriculture	9.38	50.00	14.29	100.00	25.00	45.45	0.00	0.00	**10.14**
Data management software	12.5	0.00	28.57	0.00	50.00	45.45	20.00	50.00	**14.19**

Source: Authors.

A clear hierarchy of technology adoption in agricultural production is shown in Table 8.8. With a 36.49% overall adoption rate, farming advisory apps rank highest. They are especially popular amongst farmers, 59.38% of whom reported using them. This high adoption rate indicates the effectiveness of information-based, affordable, and easily accessible solutions that can be provided through smartphones.

Tools such as precision agriculture (10.14%) and data management software (14.19%) are in the middle tier of adoption. Their use is concentrated amongst non-farmer actors, especially co-operatives and technology providers, indicating that these tools are not yet widely used at the farm level.

The more sophisticated, capital-intensive technologies are at the bottom of the hierarchy, with farmers adopting them at very low rates. These include AI (4.69%), remote sensing and GIS (6.25%), IoT sensors (6.25% of farmers), and robotics in particular (1.56%). The 'intangible versus tangible' technology divide is evident from this. Intangible, information-based technologies that provide immediate informational benefits and require little capital investment are much more likely to be adopted by stakeholders, especially farmers. However, farmers are extremely risk averse when it comes to physical, hardware-based technologies that require a large upfront investment and have a more complicated return on investment. According to this pattern, economic risk, rather than a fundamental rejection of digital information in general, is the main obstacle to implementing more sophisticated technologies at this time. Although they are receptive to digital information, farmers are understandably wary of investing in digital capital.

Additionally, the data show that technology providers frequently serve as early adopters or a 'testing ground' for cutting-edge technology. Compared with farmers, their usage rates for IoT (36.36%), GIS (36.36%), and AI (36.36%) are noticeably higher. Nonetheless, the wide disparity in adoption rates between technology providers and farmers indicates a significant breakdown in technology transfer and scaling. There seems to be a 'valley of death' between the development and testing of these technologies by providers and their actual adoption and use at the farm level, where they are most needed.

8.3.2.2 Digitalisation in the Downstream Value Chain: Marketing, Finance, and Traceability

The digital ecosystem is arguably weakest in the commercial and logistical links of the value chain, according to an analysis of technology adoption in post-production activities. Although marketing and traceability tools are conceptually interesting, their actual application lags far behind, especially in the vital field of digital finance.

Table 8.9. Rate of Adoption of Digital Technologies and Digital Tools in Distribution, Marketing, and Finance by Actor (%)

Actor	Digital marketplace	Digital apps for financing and payment	Digital payment system with banks
Farmers	27.91	10.47	24.42
Wholesalers	1.16	0.00	1.16
Processors	3.49	2.33	3.49
Distributors	0.00	0.00	0.00
Co-operatives	1.16	0.00	1.16
Technology providers	6.98	2.33	5.81
Others	0.00	0.00	2.33
Blank	1.16	1.16	3.49
All	**41.86**	**16.28**	**41.86**

Source: Authors.

The overall adoption rate of digital marketplace platforms is 41.86%, as indicated in Table 8.9. Although this number appears to be moderate, it is significantly skewed by technology providers (6.98 percentage points) and farmers (27.91 percentage points). Important market intermediaries, such as wholesalers (1.16%), processors (3.49%), and co-operatives (1.16%), are not very involved. Even more concerning is the very low overall adoption rate of digital apps for financing and payment, at just 16.28%. The potential efficiency gains from e-marketplaces are undermined by the substantial transactional friction caused by the absence of strong digital financial tools. If the financial infrastructure of a digital agricultural ecosystem remains analogue, it cannot operate efficiently.

Table 8.10. Rate of Application of Digital Technologies and Digital Tools in the Digital Traceability of Farm Goods in Domestic and International Markets

Digital technology/digital tool	Share (%)
Application of sensors and IoT-based systems for sorting farm produce	28.00
Blockchain technologies to identify product and logistics information	0.00
Inbuilt QR codes or barcodes containing product information	72.00

Source: Authors.

Table 8.11. Application Rate of Inbuilt QR Codes or Barcodes Containing Product Information in the Digital Traceability of Farm Goods in Domestic and International Markets by Actor

Stakeholder	Share (%)
Farmers	30.30
Wholesalers	0.00
Processors	0.00
Distributors	0.00
Co-operatives	0.00
Technology providers	60.00
Others	100.00
Blank	66.67

Source: Authors.

The data on digital traceability reveals a significant gap between aspiration and reality. When asked which traceability tools they prefer, respondents who use such tools overwhelmingly favour straightforward solutions; for example, 72.00% of respondents prefer inbuilt QR code or barcode technology over more complicated systems such as IoT or blockchain (Table 8.10). This suggests a clear need for simple, implementable traceability.

However, Table 8.11, which describes how this preferred QR code technology is actually used, presents an entirely different picture. The actual use of QR codes for traceability is essentially non-existent throughout the main agricultural value chain, despite the strong conceptual preference. For wholesalers, processors, distributors, and co-operatives, the adoption rate is effectively zero. Although 30.30% of farmers say they use them, this figure is based on the small percentage of farmers who use traceability. Technology providers

(60.00%) are the only group exhibiting significant usage; these individuals are probably creating and testing these systems rather than utilising them in commercial trade.

A systemic failure is indicated by the discrepancy between what stakeholders claim they want, namely simple QR codes, and what is actually occurring, namely that almost no one is using them. The complexity of the technology itself is not the obstacle, as a QR code is easy to use. Instead, the source of the failure is the surrounding institutional and business ecosystem. Since the benefits of traceability primarily flow to downstream players, such as retailers and exporters, there are probably no clear standards, no regulatory requirements, and, most importantly, no financial incentives for actors such as farmers to implement traceability. This is a classic split-incentive problem, in which the farmer, who must pay for and exert effort to implement the system, does not immediately and directly benefit, which results in systemic inaction.

8.3.3 Stakeholder Needs and Aspirations for a Digital Future

Understanding the 'pull factors', or the particular requirements and priorities that fuel demand for digital solutions, is essential to promoting digitalisation successfully. The following analysis examines stakeholders' technology needs from a demand-side perspective. It shows that there are different priorities throughout the value chain and that there is a strong focus on fundamental economic issues.

8.3.3.1 Key Priorities for Digital Intervention: A Hierarchy of Needs

Stakeholders exhibit a clear hierarchy of needs when asked where they would like to use digital solutions, giving practical and financial difficulties precedence over more general societal objectives.

Table 8.12. Share of Respondents Wanting to Apply Digital Solutions to Areas in the Agriculture and Food Value Chain

Area	Share (%)
Increasing agricultural production and productivity	81.44
Reducing production/operation costs	74.23
Appropriate labour saving in agricultural production methods	56.70
Dealing with labour shortages	45.36
Enhancing the quality of farm production	49.48
Reducing post-harvest loss, and food loss and waste	49.48
Mitigating the impacts of climate change (floods, droughts, etc.)	46.39
More environmentally friendly agriculture	45.36
Exploring new marketing opportunities	45.36
Increasing food safety	46.39
Assuring consumers of the origin and quality of products	35.05

Data management: data collection, analysis, storage, transfer, and sharing	40.21
Applying for support, such as subsidies and insurance, in agriculture	45.36
Others	1.03

Source: Authors.

The majority of the top priorities are economic, as Table 8.12 illustrates. Reducing production/operation costs (74.23%) and increasing agricultural production and productivity (81.44%) are the two most frequently mentioned needs, indicating a strong emphasis on the farm's financial performance. Other pragmatic considerations include improving quality (49.48%), reducing post-harvest losses (49.48%), and labour-saving techniques (56.70%).

Importantly, goals that are more public-good oriented and abstract are ranked lower on the priority list. Much less attention is paid to needs such as reducing the effects of climate change (46.39%), encouraging more ecologically friendly farming practices (45.36%), and ensuring that consumers know where their products come from (35.05%). This indicates that stakeholders have a strong sense of 'farm-level pragmatism'. They are logically drawn to digital solutions that offer real, instant advantages for their own business operations and financial success. This does not imply that they do not care about sustainability or climate change, but rather that economics is the main driver behind their adoption of new technology. This has important implications for policy and technology development: 'green' or 'sustainable' technologies need to be framed and designed in a way that makes it evident how they also support the main objectives of cost reduction and productivity growth if they are to be widely adopted. Adoption requires the economic co-benefit, not just a bonus.

8.3.3.2 Divergent Needs Across the Value Chain: A Tale of Different Priorities

Although the general priorities are evident, a more thorough examination shows that the needs of different stakeholders vary greatly based on where they are in the value chain. This diversity shows that a 'one-size-fits-all' strategy for encouraging digitalisation is doomed to fail.

Table 8.13. Share of Actors Wanting to Apply Digital Solutions to Areas in the Agriculture and food Value Chain (%)

Area	Farmers	Wholesalers	Processors	Distributors	Co-operatives	Technology providers	Others
Increasing agricultural production and productivity	78.13	100.00	57.14	100.00	100.00	90.91	40.00
Reducing production/operation costs	71.88	50.00	85.71	100.00	100.00	81.82	40.00
Data management: data collection, analysis, storage, transfer, and sharing	50.00	0.00	71.43	100.00	100.00	72.73	40.00
Increasing food safety	59.38	0.00	71.43	0.00	75.00	54.55	40.00
Assuring consumers of the origin and quality of products	46.88	0.00	71.43	0.00	75.00	27.27	0.00

Source: Authors.

Table 8.13 provides a crucial comparative view of stakeholder priorities. Whilst farmers prioritise both increasing productivity (78.13%) and reducing costs (71.88%), processors are overwhelmingly focused on reducing costs (85.71%), with increasing productivity being a much lower concern (57.14%). This reflects their position in the value chain, where managing input costs and operational efficiency is paramount.

The data also reveal a significant gap in priorities related to data and traceability. The need for data management solutions is a very high priority for downstream actors, such as processors (71.43%), co-operatives (100%), and technology providers (72.73%). For farmers, however, it is a much lower priority (50.00%). A similar pattern emerges for market-facing needs. Because they are directly answerable to buyers and consumers, processors (71.43%) and co-operatives (75.00%) have a very high desire for solutions that increase food safety and reassure consumers of origin and quality. For farmers, these are less pressing concerns, at 59.38% and 46.88%, respectively.

A fundamental break in the value chain is revealed by this divergence, which is caused by misaligned incentives and information asymmetry. Farmers are rationally focused on the production side of the equation, namely growing more for less. Downstream actors are focused on the market side, namely managing costs, ensuring compliance, and meeting consumer demands for safety and transparency. This difference in perspective is a root cause of the failure of system-wide technologies such as traceability to gain traction. The actor who must bear the cost and effort of implementation (the farmer) has the least direct economic incentive to do so, whilst the actors who stand to benefit the most (processors and retailers) are further down the chain. Without mechanisms to share the costs and benefits more equitably, such system-level digital solutions will continue to stall.

8.3.4 A Multifaceted Analysis of Barriers to Digital Adoption

The path to a digitalised agricultural sector is obstructed by a complex and interrelated set of challenges. This section systematically dissects these barriers, moving beyond a simple list of problems to show how they are interconnected and experienced differently by various stakeholders. The analysis reveals that the obstacles are foundational, spanning infrastructure, human capital, finance, and institutional governance.

8.3.4.1 The Foundational Deficit: Infrastructure and Environment

Before any digital solution can be considered, fundamental physical-world prerequisites must be in place. The data show that the Philippines faces a dual deficit in both physical and digital infrastructure, creating a formidable barrier to progress.

Table 8.14. Challenges, Limitations, and Infrastructure Obstacles When Applying Digital Technology and Digital Tools

Challenge	Share (%)
Availability of uninterrupted electricity supply	50.00
Access to broadband internet access	58.00
Farmers' land size	30.00
Climate-induced natural disasters	50.00
Underdeveloped mechanisation (lack of equipment and tools)	57.00

Source: Authors.

Table 8.14 identifies the top five infrastructure challenges as perceived by all respondents. The two most significant are access to broadband internet (58%) and underdeveloped mechanisation (57%). The fact that a lack of physical machinery is cited almost as frequently as a lack of internet connectivity is a crucial finding. It reveals that the challenge of digitalisation is not just digital; it is deeply physical. Many farms have not yet reached a baseline level of mechanisation that would allow them to effectively integrate digital tools. For instance, precision irrigation sensors are not very useful without an automated irrigation system to regulate them. This implies that digitalisation must be a component of a larger agricultural modernisation strategy that also involves investments in fundamental machinery and equipment.

Table 8.15. Challenges, Limitations, and Infrastructure Obstacles When Applying Digital Technology and Digital Tools by Actor (%)

Challenge	Farmers	Wholesalers	Processors	Distributors	Co-operatives	Technology providers	Others	Blanks	All
Access to broadband internet access	59.38	100.00	42.86	100.00	25.00	72.73	20.00	50.00	**57.00**
Underdeveloped mechanisation	60.94	0.00	57.14	100.00	100.00	54.55	0.00	50.00	**57.00**

Source: Authors.

Table 8.15's comparative data highlight how widespread these issues are. Access to broadband internet is a common issue, mentioned as a significant obstacle by distributors (100%), wholesalers (100%), farmers (59.38%), and even technology providers (72.73%). One particularly significant finding is that internet access problems are more common amongst technology providers than amongst farmers. This shows that the issue is not just last-mile connectivity to distant farms, but rather a structural flaw in the country's digital infrastructure that prevents supply-side agri-tech solutions from being developed, tested, and implemented. Innovation is stifled before it even reaches the end user as a result of this bottleneck. For almost all parties involved in physical production and logistics, including farmers (60.94%), processors (57.14%), and co-operatives (100%), inadequate mechanisation is a serious problem.

8.3.4.2 The Human Element: Skills, Literacy, and Mindsets

In addition to infrastructure, a major obstacle is the lack of human capital. According to the analysis, the issue is less about basic 'digital literacy' than about the failure of the wider ecosystem of training, support, and institutional culture failing to adjust to the digital age.

Table 8.16. Challenges, Limitations, and Human Resource Obstacles When Applying Digital Technology and Digital Tools by Actor (%)

Challenge	Farm	s Whole	s Proce	s Distrib	erativ op Co	Techn pro	Other	Blank	All
Digital literacy on available and potential digital technologies	62.50	50.00	71.43	100.00	75.00	54.55	0.00	16.67	**57.00**
Lack of extension workers and digital technology service providers with digital skills	60.94	0.00	42.86	1.00	50.00	54.55	40.00	50.00	**56.00**
Lack of digital skills or training at the farm level	65.63	0.00	42.86	1.00	50.00	81.82	20.00	33.33	**60.00**
Lack of digital skills or training along the value chain	12.50	0.00	71.43	1.00	50.00	36.36	0.00	0.00	**20.00**
Conservative attitudes, such as resistance to change	14.06	50.00	57.14	0.00	75.00	45.45	0.00	33.33	**24.00**

Source: Authors.

According to Table 8.16, the biggest human resource issue overall (60.00%) is a lack of digital skills or training at the farm level. Most revealingly, technology providers (81.82%) and farmers themselves (65.63%) cite this frequently. This suggests that, from the standpoint of technology developers, the single largest obstacle to market expansion is the skills gap amongst their target clients.

Importantly, the data indicates that this skills gap is a systemic failure of the agricultural support system rather than just an issue at the farmer level. The scarcity of extension agents who possess digital skills is a significant challenge, according to 60.94% of farmers and 56.00% of all respondents. This illustrates how the conventional method of training farmers and disseminating technology is itself unprepared for the digital era. A vicious cycle results from this: farmers are unable to learn because their assigned teachers are not qualified. Therefore, institutional failure rather than farmer deficiency is the issue.

It is interesting to note that the data dispel the popular myth of the 'conservative, change-resistant farmer'. Although 24.00% of respondents cited conservative attitudes as a barrier overall, farmers themselves reported this at a very low rate (14.06%). The intermediary actors who view conservative attitudes as a significant problem are wholesalers (50.00%), processors (57.14%), and co-operatives (75.00%). This implies that established mid-stream companies may actually have a great deal of institutional inertia and that farmers may be more receptive to innovation than the rest of the value chain acknowledges.

8.3.4.3 The Financial Hurdle: Cost, Incentives, and Access to Capital

Any decision regarding the adoption of technology must take economic barriers into account. According to the data, there are notable differences in how costs are perceived throughout the value chain, which suggests varying degrees of digital maturity and unique financial difficulties.

Table 8.17. Financial Challenges, Limitations, and Obstacles When Applying Digital Technology and Digital Tools (%)

Challenge	Farm	s Who	s Proc	s Distr	erat op Co	pr Techn	Othe	Blan	All
High cost of adopting new technologies	20.31	50.00	71.43	100.00	50.00	72.73	20.00	83.33	**36.00**
Lack of financial incentives for developing infrastructure and training programmes	17.19	0.00	28.57	1.00	50.00	63.64	40.00	66.67	**29.00**
Limited public support for the uptake of digital technologies	12.50	0.00	14.29	0.00	50.00	72.73	40.00	50.00	**24.00**
Access to concessionary loans and credit	9.38	0.00	14.29	0.00	25.00	36.36	0.00	16.67	**13.00**

Challenge	Farm	s Who	s Proc	s Distr	erat op Co	pr Techn	Othe	Blan	All
Others*	0.00	50.00	0.00	1.00	25.00	0.00	20.00	0.00	**4.00**

* Includes financial challenges 'to be studied' and issues with budget allocation for farmers.
Source: Authors.

The largest financial obstacle overall (36.00%) is the high cost of adopting new technology, but Table 8.17's stakeholder breakdown is very instructive. For processors (71.43%), distributors (100%), and technology providers (72.73%), who deal with more complex and costly enterprise-level software and hardware, cost is a major obstacle. On the other hand, it ranks as a surprisingly low barrier for farmers (20.31%).

This does not imply that farmers can afford technology. Instead, it shows that farmers are using digital technology at a different level. Farmers are mostly using free or inexpensive advisory apps, as shown in Table 8.8. The expensive technologies that downstream players are grappling with are not yet given much thought by them. Since they are not yet in the market for those items, 'high cost' does not appear to be their main financial obstacle. Prior to the particular issue of high technology costs, their main financial obstacle is probably a more basic one: they do not have access to any investment capital. Farmers are stuck at the low-cost or no-cost entry level, whereas other actors are reaching a financial wall at a more advanced stage, indicating varying degrees of digital maturity.

8.3.4.4 The Institutional Framework: Policy, Co-ordination, and Governance

With the exception of mandatory online submissions for permit applications and renewals, online payments, and the study's revelation that there is a push for digitalisation in agriculture, few respondents are aware of digitalisation regulations. The success of digitalisation depends on a stable and supportive institutional environment. Stakeholder perceptions reveal a widespread lack of trust and a conviction that the policy framework is unpredictable and inadequate.

Table 8.18. Institutional Challenges, Limitations, and Obstacles When Applying Digital Technology and Digital Tools (%)

Challenge	Far	s Wh	s Pro	s Distr	erati op Co	Techn	Oth	Blan	All
Limited policy instruments and framework conditions that support agricultural digitalisation	67.19	50.00	42.86	0.00	100.00	54.55	60.00	16.67	**61.00**
Lack of intergovernmental co-ordination and/or organisational structure	42.19	0.00	14.29	100.00	75.00	54.55	20.00	0.00	**39.00**
Inconsistent government strategies and frequent changes in farm policy	64.06	50.00	57.14	100.00	50.00	36.36	40.00	0.00	**55.00**
Lack of co-ordinated operations amongst public–private and local stakeholders	43.75	0.00	42.86	100.00	50.00	54.55	20.00	33.33	**43.00**
Others*	0.00	0.00	0.00	0.00	0.00	9.09	20.00	0.00	**2.00**

* Includes unfair trade policies imposed by distributors or buyers; hidden costs in warehouse and shipping activities; changing policies from the Department of Agriculture–Bureau of Agriculture and Fisheries Standards (DA-BAFS) regarding organic certification validity; and redundant information required on DA-BAFS questionnaires.
Source: Authors.

According to Table 8.18, the two main institutional challenges are inconsistent government strategies and frequent changes in farm policy (55.00% overall) and limited policy instruments and framework conditions (61.00% overall). Farmers are particularly concerned about these issues, as evidenced by the 67.19% who cite inadequate policy frameworks and the 64.06% who cite inconsistent policy. This suggests a lack of trust in the government is the main institutional obstacle. Long-term investment in digital technologies is discouraged by the high-risk atmosphere created by the perception of an insufficient, erratic, and unpredictable policy environment. It makes sense that stakeholders are reluctant to commit funds and resources when they worry that a sudden change in policy will make their investments obsolete or unsupported, especially for farmers who make a living on thin margins. The lack of any one particular regulation serves as a weaker deterrent than this policy instability.

8.3.4.5 Data-specific Obstacles: Availability, Security, and Usability

The difficulties specific to managing digital data become more apparent as digitalisation advances. The information shows that whilst people are becoming more conscious of these problems, there is still a large disparity in how each value chain actor perceives risk.

Table 8.19. Challenges, Limitations, and Obstacles in Digital Data Management and Information Transfer When Applying Digital Technology and Digital Tools (%)

Challenge	Farr	s Whc	s Proc	s Distr	- er Co op	Tech	Othe	Blar	All
Digitalised data availability and the cost of digitalisation	57.81	50.00	71.43	100.00	75.00	54.55	20.00	66.67	**58.00**
Lack of facilities for data provided by the public or private sector, such as soil maps and market information	50.00	50.00	14.29	0.00	50.00	45.45	0.00	33.33	**43.00**
Cybersecurity threats	9.38	0.00	71.43	0.00	50.00	45.45	0.00	50.00	**21.00**
Software management in local languages for data integration and data sharing	10.94	0.00	42.86	0.00	50.00	27.27	20.00	16.67	**17.00**
Others	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	**1.00**

Source: Authors.

The availability of digitalised data and the associated costs are the most common data-specific challenges, as reported by 58.00% of respondents (Table 8.19). This illustrates the cost of producing new digital data, as well as the challenge of obtaining necessary datasets, such as soil maps or comprehensive market data.

The most startling discovery in this area, though, is the enormous disparity in perceptions of cybersecurity risks. In total, only 21.00% of respondents cited cybersecurity as a challenge. However, this average conceals a wide gap. For processors (71.43%), co-operatives (50.00%), and technology providers (45.45%), it is a major concern. However, only 9.38% of farmers cited it, making it virtually a non-issue for them.

This discrepancy indicates a 'data maturity gap' throughout the value chain. The risks of data breaches and cyberattacks are well known to downstream actors, such as processors, who deal with sensitive consumer information, financial transactions, and commercial data. Farmers, on the other hand, have not yet started to widely consider the security implications of their digital activities because they are primarily creating raw production data for their own use. The growth of an integrated and reliable data-sharing ecosystem could be threatened in the future by this disparity in risk perception. Farmers will become more vulnerable to cyber threats as they use digital tools to generate more valuable data, but their awareness of these threats is currently far lower than that of other chain actors.

8.3.4.6 The Role of Public and Private Sector Support

Private sector support for agricultural digitalisation in the Philippines is still in its infancy, and the vast majority of stakeholders view it as having a small and primarily transactional impact. From the viewpoint of those on the ground, the private sector is not yet a primary driver of digital transformation in agriculture, as evidenced by the overwhelming 71.00% of survey respondents who say they have received no support at all from the private sector for implementing digital technologies (Table 8.20).

Table 8.20. Receipt of Private Sector Support for the Adoption of Digital Technologies and Tools

Support received	Share (%)
Yes	25.00
No	71.00
Unsure	4.00

Source: Authors.

The sources of support are illuminating for the 25.00% of stakeholders who do report receiving aid. According to the data, traditional agricultural actors are more likely to provide support than a specialised, contemporary agri-tech ecosystem. As shown in Table 8.21, a comparatively small share of support providers are devoted technology companies, such as startups (6.25%) and multinational corporations (5.00%). The largest single source is the 'others' category, which includes organisations such as fertiliser companies, shipping and banking companies, and farmer co-operatives. This suggests that a large portion of the current support for digitalisation is being packaged with existing goods and services (e.g. a fertiliser company providing a soil-testing app) rather than coming from a thriving, independent agri-tech sector.

Table 8.21 Private Sector Support for Adopting Digital Technologies and Tools by Private Sector Type

Private sector type	Share (%)
Local farm enterprises	18.75
Startups	6.25
Multinational companies	5.00
Subtotal: Agri-tech and enterprises	**30.00**
'Others' category (illustrative breakdown)	**(43.75)**
-- Fertiliser companies, banks, and shipping firms	*[Primary]*
-- Co-operatives	*[Primary]*
-- Family and informal networks	*[Primary]*
-- Extension service providers	*[Component]*

Note: 'Others' includes co-operatives, banking and shipping companies, fertiliser companies, family, and extension service providers engaged in curriculum development. Organisations labelled [Primary] provide digital support as part of their core business operations, whereas those labelled [Component] contribute enabling services such as training and curriculum development.
Source: Authors, 2025.

The [primary] annotation is applied to organisations whose primary function is to supply the agricultural industry with essential goods and services. Usually, the assistance they provide for digitalisation is a continuation of their primary business operations. For instance, to better target the use of its main products, a fertiliser company may provide a digital app for soil analysis. To make financial transactions easier for its agricultural customers, a bank may launch a digital payment platform. A digital logistics tool for tracking produce shipments could be offered by a shipping company. In these situations, the digital tool supports their main business function. According to the analysis, these well-established companies are combining digital solutions with their conventional offerings to provide a large portion of the private sector's current support.

Rather than referring to a full product or service, the [component] annotation describes entities that offer a particular, frequently helpful, piece of the larger digitalisation puzzle. Although they play a vital role in the ecosystem, they frequently concentrate on training or enabling. For example, curriculum development is mentioned in relation to extension service providers. Their role is to develop the human capital and skills required for stakeholders to use the technology efficiently, not to supply the technology itself. They provide the training component, which is necessary for the technologies of other key actors to be adopted.

The distinction essentially draws attention to the distinction between actors in the private sector who provide digital tools as part of their primary business ([primary]) and those who assist in the use of those tools ([component]). This makes it clearer that there is still a lack of a distinct, stand-alone agri-tech ecosystem and that the majority of current support is incorporated into the agricultural value chain.

The nature of the support is even more telling than its source. In contrast to meaningful, long-term capacity building, the engagement is strongly biased towards marketing and introductory activities (Table 8.22). The most common type of support is demonstrations for the introduction of equipment (31.58%), which is essentially a sales and lead generation activity. Training on the use of digital services (24.56%) comes next and is frequently connected to a particular product trial or purchase. Crucially, one of the least prevalent types of aid is direct financial support for purchasing digital solutions (15.79%), which indicates that the private sector is reluctant to assist stakeholders in overcoming the main obstacle of high upfront costs.

Understanding the current role of the private sector requires an understanding of this 'support versus sales' dichotomy. The private sector's engagement is framed as transactional rather than developmental due to the frequency of demonstrations and the lack of funding. Because it ignores the fundamental financial and structural obstacles that farmers and other value chain participants face, the current private sector model is therefore inadequate for promoting broad, equitable adoption. This perception explains why a stakeholder may report having an 'interaction' with a company whilst also claiming they received 'no support'.

Table 8.22. Private Sector Support Received for Adopting Digital Technologies and Tools by Type of Support

Support type	Share (%)	Qualitative interpretation/example
Demonstrations for the introduction of equipment	31.58	Sales-oriented; showcasing a drone or software to generate a lead. Perceived as a transaction, not a partnership.
Training on the use of digital services	24.56	Basic operational training for a specific app or platform; often post-purchase or part of a trial.
Appropriate use of digital data services and marketplaces	21.05	Guidance on how to list products on an e-commerce site or interpret data from a provided service.
Financial support for purchasing digital solutions	15.79	Direct subsidies, preferential loans, or discounts on technology. The least common form of substantive support.
Others (e.g. provision of seeds and automation)	7.02	In-kind support or specific project-based assistance (e.g. funding a pilot for mechanical harvesters).

Note: 'Others' includes support received from the private sector such as funds to develop solutions; provision of seeds; technology apps; and automation, specifically mechanical harvesting.
Source: Authors.

A limited and inconsistent pattern of government support for the adoption of digital technology was noted in addition to private sector initiatives. Just two-thirds of respondents to the survey reported receiving financial assistance, and all of them thought it was adequate, which is a positive indication of the impact of support. Despite being more frequently received (75%), technical support was considered adequate in 33% of the cases, suggesting a gap in quality or relevance. Remarkably, none of the respondents said they had received in-kind assistance from the government in the form of tools or electronic devices. These results underline the need for more consistent and focused government support, particularly in non-monetary forms that facilitate actual implementation at the ground level, and they confirm previous worries about disjointed institutional mechanisms.

Table 8.23. Government Support for Digital Technology Adoption

Type of support	Received (%)	Sufficient amongst those who received support (%)
Financial	66.70	100.00
Technical	75.00	33.00
In-kind	0.00	N/A

Source: Authors.

The survey offers important insights into how stakeholders view the role of the public sector, even though it did not directly collect quantitative data on the proportion of respondents receiving particular types of government assistance. The results imply that although the government's policy direction is appreciated, there is a notable discrepancy between its intention and its practical effects, with many stakeholders viewing public support as patchy and uneven.

'Limited public support for the uptake of digital technology', which was mentioned as a challenge by 24.00% of all respondents, is a significant financial barrier that stakeholders identified. Technology providers (72.73%) and co-operatives (50.00%), the very entities necessary for creating and expanding digital solutions, are especially affected by this perception. This suggests that organisations attempting to promote digitalisation from a supply and aggregation perspective perceive a glaring lack of support from the government.

This feeling of insufficient assistance stems from more general institutional issues. There is a crisis of confidence in the policy environment, according to the survey. The two main institutional barriers cited by the majority of stakeholders are inconsistent government strategies and frequent changes in farm policy (55.00%) and limited policy instruments and framework conditions that support agricultural digitalisation (61.0%). Farmers are particularly affected by this instability, as evidenced by the fact that 64.06% of them cite inconsistent policies as a major barrier. This fosters a high-risk environment that deters long-term investment in digital tools because stakeholders worry that abrupt changes in policy could jeopardise their work.

Stakeholders still have faith in the government's role despite these serious criticisms. A total of 84.85% of respondents said they agreed (50.00%) or slightly agreed (34.85%) that current policies are beneficial. This apparent contradiction implies that whilst stakeholders acknowledge and support the government's declared digitalisation goals, they believe the existing frameworks and support systems are inadequate, unreliable, and lack the power to be genuinely transformative. The reality of an institutional framework that is not yet strong enough to de-risk their transition into a digital future tempers the goodwill that is present.

8.4 Outlook, Recommendations, and Conclusion

Digital technologies have the potential to revolutionise the Philippine agriculture industry at this critical juncture. This section summarises the report's conclusions, discusses stakeholder viewpoints on new technologies and regulations, and provides evidence-based suggestions for resolving issues and maximising the benefits of digitalisation.

8.4.1 Key Findings and Future Outlook

Stakeholders acknowledge that disruptions brought on by climate change can both encourage and hinder the adoption of digital solutions. Significant challenges are presented by natural disasters and erratic infrastructure; according to half of respondents, weather-related effects are just as significant as unstable electricity. However, 46.39% of respondents prioritise using technology to lessen the effects of climate change, such as droughts and floods, indicating that digital tools are also considered crucial for climate adaptation. Nevertheless, the main forces behind decisions about technology adoption continue to be economic imperatives, particularly raising productivity (81.44%) and cutting costs (74.23%).

Table 8.24. Predicted Digital Technologies That Will Have the Greatest Impact on the Future (Medium-Long Term) of Agriculture in ASEAN (%)

Digital technology	Farn	s Who	s Proce	s Distri	- Co er op	PP Tech	Othe	Blan	All
Drones	57.81	0.00	28.57	100.00	75.00	81.82	40.00	33.33	**56.00**
IoT sensors	31.25	50.00	28.57	100.00	25.00	72.73	20.00	33.33	**36.00**
Artificial intelligence	40.63	50.00	14.29	100.00	25.00	63.64	40.00	50.00	**42.00**
Robots	28.13	0.00	0.00	0.00	25.00	45.45	0.00	33.33	**26.00**

Digital technology	Farm	s Who	s Proce	s Distri	- Co er op	Tech PP	Othe	Blan	All
Automation	39.06	0.00	71.43	100.00	50.00	63.64	20.00	50.00	**44.00**
Digital marketplace and e-commerce	78.13	50.00	100.00	100.00	25.00	81.82	80.00	83.33	**78.00**
Big data analytics	28.13	0.00	42.86	100.00	75.00	45.45	20.00	16.67	**32.00**
Blockchain	17.19	0.00	14.29	0.00	25.00	45.45	0.00	33.33	**20.00**

Source: Authors.

There is no question about the results shown in Table 8.24. According to 78.00% of all respondents, e-commerce and digital marketplaces will have the biggest impact in the future. Almost every stakeholder group, including farmers (78.13%), processors (100%), distributors (100%), and technology providers (81.82%), exhibits remarkably consistent sentiment. Automation (44.00%) and drones (56.00%) come in second and third, respectively, but remain far behind.

This broad agreement highlights the most acute issue with the current agricultural system: a lack of efficient, transparent, and direct market access. The future that stakeholders most want is one in which they are able to communicate directly with buyers, eschewing conventional middlemen and achieving greater price transparency, despite the significant attention surrounding cutting-edge technologies such as AI and blockchain. This research clearly tells investors and policymakers that the digital infrastructure, financial systems, and logistical networks that support a strong e-commerce ecosystem for agriculture should be the primary focus of digitalisation initiatives.

8.4.2 Policy Perceptions and Calls for Action

Although 84.85% of stakeholders have a positive opinion on government policies that support digital agriculture, this opinion is somewhat tempered by ambivalence (Table 8.25). Only 50% strongly agree that policies are beneficial, and more than one-third only partially agree. This implies that although policies are seen as progressing, they lack the resources, consistency, and enforcement necessary to be genuinely revolutionary.

Table 8.25. Opinions on Policies Aimed at Adopting Digital Technology and Digital Tools

Opinion	Share (%)
Agree	50.00
Slightly agree	34.85
Neither	9.09
Slightly disagree	3.03
Disagree	3.03

Source: Authors.

Despite their optimism, stakeholders are not entirely persuaded by the current initiatives. They cite institutional obstacles that undermine confidence, such as incoherent frameworks and insufficient assistance. By implementing a more stable, well-resourced, and incentive-driven policy framework that lowers investment risk and promotes wider adoption, the government has a crucial chance to build on this goodwill.

8.4.3 Challenges and Strategic Recommendations

Significant systemic barriers to digitalisation are identified in this study, including a sharp contrast between the widespread use of low-cost information services and the near-complete absence of capital-intensive technologies such as IoT and robotics; a lack of physical infrastructure, including rural broadband and mechanisation; an inadequate agricultural extension system that is unable to meet farmers' needs for digital skills; and a private sector engagement that is primarily transactional rather than ecosystem-building.

A thorough, multidimensional approach is necessary to realise the transformative potential of digital agriculture:

- **Make a national agricultural e-commerce ecosystem a priority:** To satisfy the common, top-priority need for improved market access, develop the entire value chain, including digital payments, reasonably priced logistics, cold chain solutions, and transparent digital trade standards.
- **Address dual infrastructure gaps:** To enable simultaneous modernisation of both physical and digital infrastructure, invest jointly in mechanisation access (through financing and co-operatives) and expand rural broadband.
- **Retrain extension agents** to be tech-savvy advisors or 'tech champions' who can effectively and continuously train farmers in digital skills to close the gap between farmers and technology providers. This will revolutionise the agricultural extension system.
- **Create a consistent, incentive-based policy environment:** De-risk technology investments for farmers, downstream value chain participants, and private sector infrastructure providers by establishing a long-term, transparent, consistent policy

framework with targeted financial incentives.

- Encourage real public–private partnerships: Foster co-investment in shared data infrastructure, integrated digital services, affordable financial products, and long-term capacity building to shift the private sector from transactional sales to transformative collaboration.

8.4.4 Conclusion

The Philippines faces a complex, systemic challenge in achieving a digitally enabled agricultural sector that requires co-ordinated efforts across partnerships, infrastructure, skills, and policy. The Philippines can utilise technology to create a more resilient, inclusive, and productive agricultural future by focusing closely on the pragmatic priorities of stakeholders, including market access, productivity, and cost efficiency, and by establishing a stable and encouraging environment.

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Chapter 9
Towards Smart Agriculture in Thailand: Adoption, Barriers, and Policy Gaps

Suwanna Sayruamyat

9.1 Introduction

The growing population, extreme weather conditions, pests, land degradation, and market disruptions are exerting pressure on agriculture and food systems at global, regional, and local levels. The forecasted population of 723 million in the Association of Southeast Asian Nations (ASEAN) by 2030 is increasing pressure on food security, water resources, and agricultural labour. The implementation of evolving digital technologies in agriculture is crucial for future resilience and productivity in addressing these concerns. The 'ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector' were adopted by the ASEAN Ministers on Agriculture and Forestry in 2021 as a unified endeavour. In the 'ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises', adopted at the ASEAN Summit in September 2023, ASEAN leaders agreed to accelerate digital transformation to enhance productivity and resilience within agri-food systems.

In Thailand, the agriculture sector faces challenges caused by structural factors and external changes, which directly impact the productivity and competitiveness of most farmers. Attavanich et al. (2019) demonstrated that the Thai agricultural sector faces a labour shortage, with over 50% of agricultural households comprising ageing workers who frequently lack access to modern knowledge and technology. The majority of Thai farmers are smallholders, resulting in limited economies of scale in resource access, technology utilisation, and bargaining power within an extended supply chain market. The implementation of government agricultural promotion policies may lack efficiency and broad reach. The combination of these challenges, coupled with climate change and heightened global market competition, leads to low productivity and net profits amongst Thai farmers (Ratanavararak et al., 2019).

In Thailand, there is an increasing recognition in both the public and private sectors of the advancement of digital technology for the agriculture industry. This is evident in the multitude of agricultural application markets presently accessible. Nevertheless, most of these programmes provide inadequate features, are of substandard quality, and have a limited user base (Ratanavararak et al., 2019). Thus, this study aims to: (1) assess the actual status of utilisation of digital technologies in agricultural production sites and along the food value chain, focusing on best practices and applied technology; (2) identify challenges to the diffusion of digital technology utilisation in agriculture and food systems; 3) identify and analyse digital policy instruments; and (4) specify the study area to be deepened in the in-depth country case study as the next stage of this research project.

9.2 Method

A total of 120 participants were interviewed by telephone using a structured questionnaire comprising four parts: (1) the status of utilising digital technologies and tools in agriculture production and along the food value chain; (2) government initiatives to support the utilisation of digital technologies and tools; (3) private sector support; and (4) the future of digitalisation in agriculture. Purposive and snowball sampling was conducted to confirm that each participant uses digital technologies in agriculture and food systems for five main commodities: rice, fruits and/or vegetables (traditional), fruits and/or vegetables (greenhouse), livestock and poultry, and aquaculture. Their farms are located in 66 provinces, covering all regions of Thailand.

9.3 Data Analysis and Interpretation

9.3.1 Profile of Respondents

The participant demographic is characterised by a gender distribution of 66% male and 34% female. The respondent category is predominantly composed of farmers, who constitute 93% of the total sample (111 out of 120). In terms of commodity focus, fruits and/or vegetables (traditional) represent the primary agricultural activity, accounting for 48% of participants (57 individuals). Rice cultivation is also a significant component, involving 21% of participants (25 individuals). Additional commodities of interest include livestock and poultry (7%, 8 participants), aquaculture (3%, 3 participants), and fruits and/or vegetables (greenhouse) (15%, 18 participants). The distribution of participants by years of experience reveals that the largest segment possesses 5–10 years of experience, representing 50% of the sample (60 individuals). Participants with 11–20 years of experience and those with over 20 years of experience account for 21% (25 individuals) and 13% (15 individuals) of the sample, respectively. Finally, participants with less than 5 years of experience comprise 17% of the total (20 individuals).

9.3.2 Status of Using Digital Technologies

The adoption rates of various digital technologies across key segments of the agriculture and food value chain are categorised into three primary areas: production; distribution, marketing and financing; and digital traceability.

9.3.2.1 Production Technologies

The adoption of digital technologies within the production phase demonstrates variability. Farming advisory applications exhibit the highest adoption rate in this category, with 78 respondents (65%) reporting usage. They enable faster problem checking and analysis without the need to travel and provide quick advice on solutions. Internet of Things (IoT) sensors are utilised by 53 respondents (44%). Respondents stated that this technology helps monitor environmental conditions in real time and automatically control water according to the needs of plants, which is useful for decision-making in watering and pest management. Drones, employed for crop monitoring and input applications, show a lower adoption rate, with 22 respondents (18%). Respondents choose agricultural drones for spraying pesticides and fertilisers because they help reduce labour costs and direct contact with chemicals. Technologies such as robotics, automation, remote sensing and geographic information systems (GIS), artificial intelligence (AI), and precision agriculture demonstrate relatively low adoption rates, with adoption percentages ranging from 3% to 12%. Respondents use AI to analyse soil and weather conditions and predict the best time for planting and harvesting, as well as recommend appropriate amounts of fertilisers, water, and nutrients for each type of plant.

9.3.2.2 Distribution, Marketing, and Financing Technologies

Digital technologies aimed at enhancing distribution, marketing, and financing within the agricultural sector reveal varying levels of penetration. Digital marketplaces, which facilitate agricultural input procurement and farm product information dissemination, are utilised by 96 respondents (80%). Digital payment systems with banks also show a high adoption rate, with 97 respondents (81%) reporting usage. This indicates the success of the Bank of Thailand's implementation of PromptPay, launched in 2016 as a payment system infrastructure for transferring money (Bank of Thailand, 2023). Using digital payments offers convenience, speed, and cost-effectiveness, as well as saving time on travel to banks or ATMs. The system employs a password for each login, enhancing user confidence in data security (Nuchpho and Sittisak, 2019). However, digital applications for financing and payments between suppliers and buyers have a lower adoption rate, with 17 respondents (14%) indicating usage.

9.3.2.3 Digital Traceability Technologies

Technologies focused on enabling digital traceability of farm commodities within domestic and international markets present a range of adoption levels. Inbuilt QR codes/barcodes for product information are used by 52 respondents (43%). Applications of sensors and IoT-based systems for sorting farm produce and blockchain technologies for product and logistics information have limited adoption, with 8 respondents (7%) utilising each technology.

Farmers who receive support and guidance from the government on digital technology are aware of policies aimed at promoting the use of digital technology and digital guidance. The main reasons are that the government often organises training programmes and promotes the use of digital platforms by farmers, such as soil analysis systems or agricultural drones. Information about policies is disseminated through online media, applications, or consulting centres.

On the other hand, farmers who do not receive support and guidance from the government on digital technology but are still aware of policies aimed at promoting the use of digital technology and digital guidance mainly learn about digital technologies from online media and channels, such as Facebook pages, YouTube, or Line groups of farmer groups. In these Line groups, there are often officials from agricultural agencies who publicise news and provide various consultations, as well as information sharing amongst farmer groups, such as Young Smart Farmer groups or community enterprises. Some farmers also search for information themselves, including direct contact with government officials through discussions with district agricultural officers. However, the primary use of technology amongst farmers is for social communication, with less emphasis on its application to agricultural work (Attavanich et al., 2019).

In summary, Thai farmers use digital technologies and solutions in the agricultural production cycle to enhance efficiency, sustainability, and market competitiveness. This emphasises the importance of data-driven decision-making, resource optimisation, and improved market access through the adoption of digital tools and platforms (Figure 9.1).

Figure 9.1. Digital Technology Integration in the Agricultural Production Cycle

Source: Authors.

Whilst many farmers, particularly smallholders, perceive the integration of technology into their agricultural practices as unnecessary due to the perceived lack of cost-effectiveness, the Digital Economy Promotion Agency (DEPA), a Thai government agency, projects an upward trend in digital technology adoption within the Thai agricultural sector. Specifically, DEPA's 2021 survey indicates that 'smart farmers' are increasingly integrating digital tools and prioritising the transition to Agriculture 4.0 (DEPA, 2021). This shift is characterised by the increased use of agricultural machinery equipped with sensors, digital devices, and specialised software for internet-based data collection and transmission, a trend expected to escalate in the future.

9.3.2.4 Needs Areas

The perceived needs areas within agriculture and value chains were identified by the surveyed respondents. Participants were asked to indicate areas where they wish to apply digital solutions. The key findings are as follows.

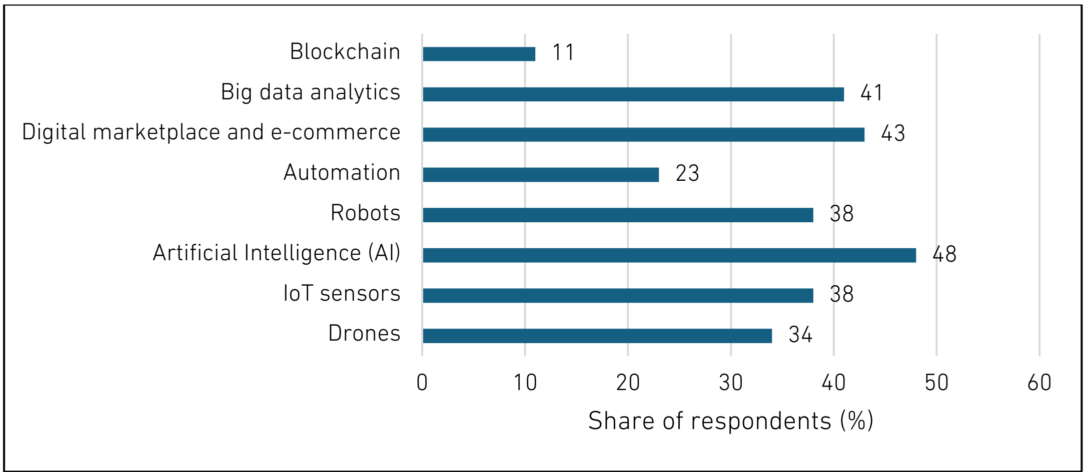
1) Enhancing production and productivity: The area with the highest endorsement is increasing agricultural production and productivity, with 77 respondents (64.17%) identifying this as a key area for digital intervention. This suggests a strong interest in leveraging digital technologies to optimise agricultural output.
2) Cost reduction and labour efficiency: Reducing production/operation costs and appropriate labour saving in agricultural production methods are also prioritised, with 66 respondents (55%) and 74 respondents (61.67%) indicating these needs, respectively. These findings highlight the importance of digital solutions in improving economic efficiency within agricultural practices.
3) Addressing labour challenges: Dealing with labour shortages is identified as a need by 47 respondents (39.17%), indicating a recognition of the potential of digital technologies to mitigate labour-related constraints in agriculture.
4) Quality and post-harvest management: Enhancing the quality of farm produce is a concern for 53 respondents (44.17%), whilst reducing post-harvest losses, food loss, and waste is identified by 24 respondents (20%). These results suggest interest in digital tools for quality control and supply chain optimisation.
5) Environmental considerations: Needs related to environmental sustainability, including mitigating the impacts of climate change and promoting more environmentally friendly agriculture, are acknowledged by 27 respondents (22.5%) and 36 respondents (30%), respectively. This indicates a growing awareness of the role of digital solutions in promoting sustainable agricultural practices.
6) Market access and consumer assurance: Exploring new marketing opportunities and assuring consumers of the origin and quality of products are identified as needs by 35 respondents (29.17%) and 33 respondents (27.5%), respectively. These findings point to the use of digital technologies to improve market linkages and enhance consumer trust.
7) Food safety and data management: Increasing food safety and data management, including data collection, analysis, storage, transfer, and sharing, are identified as needs by 25 respondents (20.83%) and 21 respondents (17.5%), respectively. This reflects the importance of digital solutions in ensuring food safety and improving data handling within the agricultural sector.
8) Support systems: Applying for support, such as subsidies and insurance, in agriculture is the least endorsed need, with only 11 respondents (9.17%) identifying it. This suggests that whilst support systems are important, they may be perceived as less critical areas for digital intervention compared with other needs.

In summary, the data indicate that respondents prioritise the application of digital solutions to enhance agricultural production and productivity, improve economic and labour efficiency, address environmental challenges, and optimise agri-food supply chain management.

9.3.2.5 Expectations for Digital Technologies

The survey results indicate farmers' perceptions regarding the potential impact of various digital technologies on the future of agriculture within the ASEAN region. AI was identified by the largest proportion of respondents (48%) as having the greatest potential impact. Following AI, digital marketplaces and e-commerce platforms were also considered significant, with 43% of respondents recognising their potential. Big data analytics were cited by 41% of respondents as a technology with substantial future impact. Technologies such as IoT sensors and robots were perceived as having a comparable level of impact, both cited by 38% of respondents. Drones were also considered important, with 34% of respondents acknowledging their potential influence. In contrast, automation was perceived as having a more limited impact, with only 23% of respondents identifying it as a key technology. Blockchain technology was viewed as the least impactful amongst the technologies listed, with only 11% of respondents anticipating it would have a significant effect on the future of agriculture (Figure 9.2).

Figure 9.2. Farmers' Perspectives on the Potential of Digital Technologies



Source: Authors.

9.4 Challenges in Adopting Digital Technologies

The adoption and effective use of digital technologies and solutions are constrained by a complex interplay of infrastructural, human resource, financial, institutional, and data-related challenges. The key challenges and obstacles impeding the adoption and effective utilisation of digital technologies and solutions are categorised into five principal areas: basic infrastructure, human resources, financial constraints, institutional limitations, and digitalised data management and information transfer.

9.4.1 Basic Infrastructure

A fundamental impediment to the integration of digital technologies is the deficiency in basic infrastructure, particularly concerning accessibility and affordability. The data highlight several key infrastructural deficits: most significantly, the disruptive impact of climate-induced natural disasters, such as floods, droughts, and landslides, which pose significant challenges to the deployment and utilisation of digital technology in the agriculture sector (56%); followed by underdeveloped mechanisation, characterised by an insufficiency of essential equipment and tools necessary for the integration of digital solutions within agriculture (38%). Further challenges include an unreliable electricity supply, which constrains the consistent operation of digital devices and systems (29%), limited access to broadband internet connectivity, a crucial element for data transmission and access to online digital resources (28%), and constraints imposed by farmers' land size, which may affect the economic feasibility of implementing certain digital agricultural technologies (22%).

9.4.2 Human Resources

Human resource limitations also constitute a critical impediment to the integration of digital technologies. Key challenges in this category include, most notably, insufficient digital literacy regarding available and potential digital technologies, which constrains effective adoption and application (57%), and inadequate digital skills or training at the farm level, limiting the capacity of farmers to utilise digital tools (41%). A shortage of extension workers and digital technology service providers possessing the requisite digital skills to support implementation (37%) further compounds these challenges, as does the lack of digital skills or training along the value chain, hindering comprehensive digital integration across the agricultural sector (20%). Finally, conservative attitudes, such as resistance to change, can impede the acceptance and adoption of new digital technologies (12%).

9.4.3 Financial Constraints

Financial obstacles also constitute significant barriers to the adoption of digital solutions. These obstacles include the high cost associated with the adoption of new technologies, which renders them inaccessible to many potential users (71%). Furthermore, there is a lack of financial incentives for developing necessary infrastructure and training programmes, discouraging investment in these critical areas (24%). Limited public support in the uptake of digital technology, reflecting insufficient prioritisation or resource allocation by public sector entities, poses an additional challenge (24%). Finally, challenges in accessing concessionary loans and credit restrict the financial capacity to invest in digital agriculture (13%).

9.4.4 Institutional Limitations

Institutional factors also play a crucial role in constraining the digitalisation of agriculture. These factors include limited policy instruments and framework conditions that support agricultural digitalisation, indicating a lack of enabling governance structures (42%). Insufficient intergovernmental co-ordination and/or organisational structure hinder the cohesive and effective implementation of digital strategies (34%). The lack of co-ordinated operations amongst public, private, and local stakeholders reflects fragmented efforts and a lack of synergistic collaboration (30%). Furthermore, inconsistent governmental strategies and frequent changes in farm policy create instability and uncertainty that impede long-term digital investments (26%).

9.4.5 Digitalised Data Management and Information Transfer

Challenges related to digitalised data management and information transfer further compound the difficulties in leveraging digital technologies. These challenges include limited digitalised data availability, and the high costs associated with digitalisation processes, restricting access to essential data (52%). Furthermore, there is a lack of necessary facilities for critical data provided by the public or private sector, such as soil maps and market information, hindering informed decision-making (28%). Cybersecurity threats pose risks to data integrity and security (22%). Additionally, software management challenges, including the lack of software in local languages for effective data integration and sharing, create further obstacles (13%).

Based on the survey responses regarding support from the government for using digital technologies and introducing digital solutions, the data reveal varying levels of support across different types. Technical support (training, education, etc.) was the most commonly received form of support (80.00%), whilst financial support (subsidies, access to credit, tax incentives, etc.) and in-kind support (tools, mobile phones, digital equipment, etc.) were received by 48.33% and 40.83% of respondents, respectively. Amongst those who received support, technical support was also rated as the most sufficient (45.00%), compared with financial support (12.50%) and in-kind support (10.00%), indicating a discrepancy between the provision and the perceived adequacy of support (Table 9.1).

Table 9.1. Government Support Received by Farmers

Type of support	Received support (%)		In case of yes (%)	
	Yes	No	Sufficient	Insufficient
Financial support (subsidies, access to credit, tax incentives, etc.)	48.33	51.67	12.50	36.67
Technical support (training, education, etc.)	80.00	20.00	45.00	35.00
In-kind support (tools, mobile phones, digital equipment, etc.)	40.83	59.17	10.00	30.00

Source: Authors.

9.5 Private Sector Involvement

Survey results indicate that private sector involvement in the utilisation of digital technologies and tools in agricultural production and the food value chain is present but not pervasive. Overall, 21% of respondents reported receiving private support, whilst a substantial majority (72%) expressed they did not receive such support. This emphasises that the primary responsibility for promoting adoption of digital technology in agriculture currently falls outside the private sector. Amongst those who did receive private support, it originated from a range of sources, including multinational companies (32%); subsidiaries of retail companies, specifically buyers or intermediaries (32%); local farm enterprises (20%); and startups (16%). The support that farmers received from the private sector included financial support to purchase digital technological solutions (7%), training on the use of digital services (18%), demonstrations for the introduction of equipment (11%), and support for the appropriate use of digital data services and marketplaces (3%). These results highlight that training on the use of digital services is the most common form of support, whilst financial support to purchase technology is less frequent. Support for using digital data services and marketplaces is the least common.

However, integrated farms are increasingly incorporating digital technology to enhance production quality and enable traceability back to the source. Processed food manufacturers are also utilising contract farming to manage their supply chains with greater stability and sustainability. Company support extends beyond mere production; companies also provide expert guidance and supervision, from the initial stages of land preparation through to final product distribution. This is achieved through the adoption of digital technologies and new innovations to boost yields and reduce costs for farmers. Examples include the use of agricultural drones for analysing plant health and pest infestations and smart drip irrigation systems for efficient water usage. Additionally, efforts are being made to develop crop varieties suited to Thailand's climate. Moreover, for key agricultural export commodities such as palm oil, rubber, coffee, and broiler chickens, the private sector is adapting by incorporating digital technology to prepare for the future implementation of the Carbon Border Adjustment Mechanism. In processing plants, there is a growing trend of installing solar rooftops to utilise solar energy, along with measures to reduce water consumption and recycle processing steam. This highlights the crucial role of the private sector in driving digital technology adoption in Thailand's agricultural sector.

9.6 Overview of Policy

9.6.1 Smart Agriculture Policy in Thailand

The Ministry of Agriculture and Cooperatives (MOAC), under the Thailand 4.0 initiative, has implemented several policies and initiatives aimed at promoting the use of digital technology in the agricultural sector since 2017. MOAC has formulated the Digital Action Plan for the 2023–2027. This plan serves as a framework for driving administrative operations and services through digital technology, aligning with the 20-Year National Strategy (2018–2037), the National Policy and Plan for Digital Development for Economy and Society (2018–2037), the 13th National Economic and Social Development Plan, the Digital Government Development Plan of Thailand 2023–2027, and the 20-Year Agricultural and Cooperative Strategy (2017–2036) (MOAC, 2023).

To achieve the vision of 'Secure Farmers, Prosperous Agriculture, Sustainable Agricultural Resources', MOAC has promoted the Smart Agriculture Policy, focusing on the adoption of technology and innovation to develop smart farms or agricultural plots with precision in various agricultural sectors, including crop production, livestock farming, fisheries, and greenhouse cultivation. It involves the use of automation systems and smart sensors to monitor environmental factors such as humidity, light, and temperature within farms. The initiative includes the development of a big data system for agriculture. This system is intended to serve as a crucial tool for decision-making and to guide the direction of agricultural development in the country.

The promotion and expansion of smart agriculture involve various projects aimed at expanding smart agriculture practices amongst farmers. One example is the establishment of smart agricultural learning plots, which serve as demonstration sites for the application of different technologies, such as IoT systems, laser-controlled land levelling machines, weather stations, smart water level meters, automatic watering systems, and automatic harvesters. The initiative includes projects focused on promoting new-generation agricultural entrepreneurs, also known as startup farmers. These projects are aimed at enhancing the expansion of agricultural service businesses provided by agricultural institutions and encompass Smart Agricultural Land Development Community Projects, as well as Young Smart Farmer and Smart Farmer Projects.

In 2019, Thailand saw a surge in interest from both the public and private sectors in developing digital technology for the Thai agricultural sector. Numerous agricultural applications were developed, but most offered incomplete services and were of suboptimal quality. The majority focused on providing services related to agricultural extension, knowledge dissemination, and information provision, whilst applications related to marketing, resource sharing, and finance were scarce. Furthermore, no application provided comprehensive coverage of the entire supply chain. This resulted in low user adoption and limited further development, leading to the discontinuation of many applications (Ratanavararak et al., 2019).

However, the results from the survey reveal insights into Thai farmers' awareness and intended utilisation of digital technologies and solutions. The Smart Agriculture Policy, which promotes the use of technology and innovation for the development of smart farms, was the most recognised policy amongst the respondents (83.3%). Furthermore, the Big Data Policy for agriculture, aimed at creating a big data system to support agricultural decision-making and planning, was also acknowledged by a significant portion of the farmers (53.33%).

Regarding the plans to promote and expand smart agriculture, 44.17% of the respondents were aware of initiatives such as smart agricultural learning plots, which demonstrate the use of various technologies, including IoT systems, laser-controlled land levelling machines, weather stations, smart water level meters, automatic watering systems, and automatic harvesters. Additional policies and initiatives recognised by the farmers include: (1) Young Smart Farmer and Smart Farmer Projects (84.17%); (2) projects promoting new-generation agricultural entrepreneurs (startup farmers) (54.17%); (3) projects upgrading the expansion of agricultural service businesses (service providers) of agricultural institutions (25.0%); and (4) Smart Agricultural Land Development Community Projects (25.83%).

To promote smart agricultural service businesses (service providers), the plan includes several projects, such as projects supporting interest-free revolving funds to develop smart agricultural tourist attractions, recognised by 38.33% of farmers; projects promoting tourism in smart agricultural farm plots, recognised by 40.00%; and projects developing training courses to promote effective learning of smart agricultural technology usage for farmers, recognised by 36.67%. These initiatives indicate a multifaceted approach to fostering the growth of smart agricultural service providers through financial support, promotion of agricultural tourism, and the enhancement of farmers' technological literacy.

9.6.2 Effectiveness of the Smart Agriculture Policy

The Thailand 4.0 policy in 2017 marked the starting point for several measures supporting the use of digital technology in the agri-food systems. For example, incubation and acceleration activities for agricultural technology startups were introduced to allow potential private sector entities to become developers and service providers. Under this policy, MOAC promoted the use of existing networks to enhance technology adoption through the Young Smart Farmer project, which brings together new generations who are enthusiastic about and interested in agriculture to meet and spark new ideas that can lead to innovation.

Nevertheless, the above activities concentrate on the supply side, such as digital technology training projects that still focus mainly on entrepreneurs, agricultural leaders, and startups, rather than small-scale farmers, who are equally important. In terms of data, the government has initiated an open data platform to gather data in one place for easy access, but the disclosure of data for the private sector and researchers to utilise is still limited. Furthermore, the disclosed data are at the macro, regional, and national levels, which poses significant limitations for individual-level analysis and thus limits the development of digital technology by the private sector. This is partly due to the Personal Data Protection Act B.E. 2562 (2019), which came into effect on 1 June 2022. Government agencies are therefore concerned about providing farmers' data to the private sector and researchers. However, this law aims to address the increasing problem of personal data breaches, for example the trading of phone numbers and other personal information without the data owner's consent, which is often found in the form of advertising calls or scams. The use of anonymised individual-level data for analysis and problem-solving at the individual and household levels is permissible and would be very beneficial to the country's agri-food systems.

Furthermore, technology comes at a high economic cost, especially for small-scale farmers. Coupled with differences in factors amongst farmers themselves, such as age, learning ability, motivation, and behavioural biases, government technology transfer is often broad-based and overlooks these factors. This contributes to the inefficiency in motivating farmers to widely adopt technology (Ratanavararak et al., 2019).

Farmers' perceptions of government initiatives, programmes, and support related to the Smart Agriculture Policy in Thailand reveal a range of opinions and experiences. Some programmes, such as the Young Smart Farmer and Smart Farmer programmes, are viewed positively, particularly when deemed relevant and effective in enhancing productivity and reducing labour costs. However, there are widespread concerns regarding the broader policy framework. Farmers have expressed that policies are often perceived as difficult to implement, unrealistic, and inconsistent, failing to adequately cater to the diverse needs of farmers and often neglecting the requirements of grassroots farmers in favour of larger entities such as traders and processors. Issues of accessibility, effective implementation, relevance, and practical support are central to these criticisms, with farmers expressing a need for more tangible and sustained assistance. A sense of exclusion is prevalent, with reports of farmers feeling unable to participate or lacking a comprehensive understanding of the initiatives, whilst past participants report a sense of abandonment due to insufficient follow-up.

Additionally, some farmers have indicated that the policies do not address their primary concerns, specifically the challenges related to sales rather than production, highlighting a disconnect between the agricultural and commercial sectors. Farmers have also called for more hands-on practical training, as opposed to theoretical presentations, and have raised concerns about access to resources such as big data and revolving funds, citing stringent conditions. The desire for tangible support, such as support aimed at improving soil quality, rather than mere policy announcements, is a recurring theme, with some farmers expressing that support is often contingent on prior achievements, a criterion they view as unhelpful. The need for continuity in programmes and support is also emphasised. Criticisms of the policies' practicality and calls for improved knowledge dissemination and guidance from relevant agencies are common. Farmers have also requested assistance with plant and soil selection tailored to specific local conditions, referencing agricultural practices in countries such as Israel as a benchmark.

9.7 Way Forward

The restructuring of the country to support the use of digital technology in agri-food systems is still a goal that Thailand should aim to achieve. In the next stage of this research project, the expansion of digital technology adoption in the agriculture and food sectors should be continuously monitored, particularly within the Smart Farmer and Young Smart Farmer groups, as well as amongst rice and fruit producers, such as durian producers. These groups exhibit a higher intensity of digital technology usage compared with other farmer groups, positioning them as potential learning centres for farmers who overlook the necessity of digital technology in agriculture. This could encourage broader interest and adoption in the future.

In terms of policy, the government should focus on developing essential infrastructure and supporting the use of digital technology for agriculture and food, including the following:

1) Driving the adoption of agricultural digital technology and empowering farmers by addressing internet connectivity and cost. The government should invest in the development of strong and stable internet signals, ensuring coverage in agricultural regions. Moreover, reducing the cost of internet access through both mobile and broadband services is necessary. Lower internet usage costs for farmers will remove financial barriers to accessing agricultural digital technologies.

2) Providing financial support to private companies and social enterprises to develop agricultural digital technologies, such as sensors and IoT. Financial support would encourage companies to research, develop, and test digital solutions tailored to the specific needs of farmers. It would lead to the creation of user-friendly, practical, and cost-effective digital technologies and solutions in areas such as precision farming, crop and livestock management, pest and disease control, market assessment, and

traceability in agri-food systems. The availability and accessibility of agricultural digital technologies and solutions could be increased by supporting the growth of companies specialising in agriculture through subsidies, grants, tax reductions, and low-interest loans, depending on the capacity of the companies. The availability and accessibility of these technologies in the market would motivate farmers to test and identify solutions that fit their agricultural practices and requirements. Furthermore, companies and social enterprises that receive financial funding can provide training and support to help farmers learn to use their technologies and solutions effectively. This will reduce the knowledge and skills gap that is a key barrier to adoption for some farmers and small businesses. Finally, financial support can stimulate innovation in the agricultural digital technology sector, leading to the development of cutting-edge solutions. This will support the transition of agricultural practices to agricultural digitalisation and improved productivity, efficiency, and sustainability of agri-food systems in Thailand.

3) Supporting and creating an environment that fosters competition and the creation of new innovations. The government should:
    a. Promote fair competition by ensuring that the markets are not dominated by a few large players. Policy must prevent anti-competitive practices such as monopolies, unfair mergers, and price-fixing.
    b. Reduce barriers to entry by providing support for startups and simplifying and improving the regulatory processes of government services.
4) Supporting funds for public research institutions to promote the use of digital technology, including demand-side support, such as developing digital skills and knowledge for small-scale farmers, and creating the right incentives for farmers to use digital technology to improve their productivity and livelihoods. Moreover, public research would lead to breakthroughs in new ideas that can be commercialised by companies, thereby indirectly supporting the competitive ecosystem for agricultural digital technologies.
5) Improving outdated government regulations that slow down the development process. This includes consolidating similar laws from various agencies into a single framework for easier management and enforcement.

9.8 Conclusion

Digital technology is crucial for addressing pressures on food security, water resources, and agricultural labour. It can enhance productivity and resilience in agri-food systems. Digital payments, for example, offer convenience, speed, cost-effectiveness, and security. Farmers recognise the potential of digital solutions to increase production and productivity, reduce costs, improve labour efficiency, enhance quality, address labour shortages, and improve market access and consumer trust. The Thai government has implemented policies to promote digital technology in agriculture, such as the Smart Agriculture Policy and the big data system. However, support is needed to reach small-scale farmers. Private sector involvement remains limited.

Thai farmers believe that AI, digital marketplaces, big data analytics, IoT sensors, robots, and drones have the greatest potential impact on the future of agriculture. Whilst some government programmes are viewed positively, there are concerns about policy implementation, relevance, and practical support. Farmers desire more hands-on training and tangible support.

This study suggests that Thailand should focus on developing a detailed agricultural database, improving internet connectivity and affordability, providing financial support for the development of agricultural digital technologies, fostering competition and innovation for private companies, and improving outdated government regulations. These efforts are crucial for Thailand to achieve its goals in agricultural digitalisation and improve the productivity, efficiency, and sustainability of its agri-food systems.

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Chapter 10

Adoption of Digital Technologies in Vietnamese Agriculture: Stakeholder Perspectives and Challenges

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10.1 Introduction

In the context of globalisation and rapid technological advancement, digital transformation has become a key factor in enhancing the efficiency and competitiveness of Viet Nam's agricultural sector. The integration of digital technologies across the entire agricultural value chain, from production and processing to distribution and consumption, not only optimises operations but also improves product quality to meet the stringent requirements of international markets. This transformation presents new opportunities for the sustainable development of Viet Nam's agriculture.

As consumer demand for high-quality agricultural products continues to grow, the adoption of digital technology in agricultural production and value chain management has become an inevitable trend. Several agricultural sectors have successfully pioneered digital transformation, achieving significant breakthroughs in productivity and product quality, thereby increasing the value of Vietnamese agricultural products in global markets.

In crop production, particularly in rice and vegetable farming, advanced technologies have been implemented to enhance productivity and efficiency. In the Mekong Delta, Viet Nam's largest rice-producing region, drones have been widely used for pesticide spraying and automated fertilisation. Additionally, several agricultural co-operatives in the region have introduced technologies such as field monitoring cameras and Internet of Things (IoT)-based systems to optimise irrigation and pest control. Moreover, remote sensing and satellite imaging technologies are extensively utilised for weather forecasting and crop monitoring, enabling farmers to make timely and informed decisions.

In addition to crop cultivation, the livestock and aquaculture industries are also at the forefront of digital technology adoption. In livestock farming, large-scale farms have implemented automated feeding systems, utilised smart sensors to monitor animal health, and adopted modern breeding management software. In aquaculture, particularly in shrimp and pangasius farming, two of Viet Nam's key export commodities, IoT sensor technology has been deployed to monitor water quality, detect early signs of disease, and optimise feed management. These advancements not only enhance productivity but also minimise environmental impacts.

Beyond production, digital technology has also driven significant transformations in supply chains and agricultural exports. For key export commodities such as coffee, traceability and quality control technologies are being widely implemented to ensure transparency and meet the stringent requirements of international markets. Notably, blockchain technology has been piloted in the coffee supply chain, enhancing product reliability and brand value.

Despite its numerous benefits, Viet Nam's agricultural sector still faces several challenges in digital transformation. One of the most significant obstacles is farmers' access to technology, particularly in rural areas where digital literacy remains limited. Additionally, the lack of fully developed digital infrastructure hampers the widespread deployment of technological solutions. Overcoming these challenges requires close collaboration between the state government, technology enterprises, and farmers. In particular, training and raising awareness amongst farmers about the benefits of digital technology are crucial for its effective application in agricultural production.

This country case study was conducted by the Viet Nam Agricultural Market and Institution Research Institute (AMI) within the framework of the project 'Benefits and Challenges of Digitalisation in Agriculture and Food Systems for Enhanced Resilience and Improved Sustainability: Preliminary Assessment Study', led by the Economic Research Institute for ASEAN and East Asia (ERIA). The report utilises survey results from over 100 relevant stakeholders in agricultural product value chains in Viet Nam to assess the current status and potential for developing digitalisation applications in the country's agricultural sector.

10.2 Method

The data used in this report include both primary and secondary sources. Secondary data were collected from relevant documents, reports, and research articles related to the study's subject matter. Primary data were gathered from 103 stakeholders involved in the agricultural value chain in Viet Nam, including farmers, traders, input suppliers, consumers, and technology providers.

The survey questionnaire used in this study was developed by ERIA and adapted into Vietnamese by the research team to ensure contextual relevance. Data collection in the northern region was conducted directly by the research team from AMI. For the southern provinces, AMI provided training for local collaborators, who were also agricultural officers of the respective provinces, to carry out data collection and entry.

The study focuses on the rice sector to enable a comparative analysis amongst Association of Southeast Asian Nations (ASEAN) countries. Consequently, the survey sample focuses on the Viet Nam's largest rice-producing region, the Mekong River Delta, with 56 respondents, accounting for 54% of the sample. Other respondents were from provinces in the Red River Delta and Northern Mountainous areas, including Ha Noi, Nam Dinh, Bac Giang, Yen Bai, and Son La (Table 10.1).

Table 10.1. Map of Surveyed Areas

Surveyed province	Share (%)
Hanoi	22.33
Nam Dinh	4.85
Bac Giang	12.62
Son La	0.97
Ha Giang	4.85
An Giang	54.37

Source: Authors.

The main stakeholders include farmers, wholesalers, enterprises, distributors, co-operatives, technology providers, and consumers. Amongst them, farmers account for more than 81% of the total 103 respondents.

Table 10.2. Classification of Survey Respondents (%)

No.	Stakeholder	Paddy	Fruits/ vegetables (traditional)	Livestock and poultry	Aquacul ture	Other*	All
1	Farmers	100.00	0.00	0.00	0.00	0.00	81.55
2	Wholesalers	60.00	20.00	20.00	0.00	0.00	4.85
3	Businesses	100.00	0.00	0.00	0.00	0.00	2.91
4	Distributors	100.00	0.00	0.00	0.00	0.00	0.97
5	Co-operatives	80.00	20.00	0.00	0.00	0.00	4.85
6	Technology providers	0.00	0.00	0.00	0.00	100.00	0.97
7	Consumers	100.00	0.00	0.00	0.00	0.00	1.94
8	Others*	0.00	0.00	0.00	0.00	100.00	1.94
	All	**94.17**	**1.94**	**0.97**	**0.00**	**2.91**	

* Agricultural product processing.

Source: Authors.

The interviewees produce a variety of products, including rice, fruits and vegetables, livestock, and poultry. Notably, 94% of the interviewed farmers are involved in rice cultivation (Table 10.2). Farmers in the north are more diversified, whilst farmers in the south are more specialised and commercialised. Other related stakeholders, such as processors, traders, distributors, are also mostly involved in rice production, processing, and sales.

Table 10.3. Survey Sample by Gender

No.	Gender	Share (%)
1	Male	62.14
2	Female	37.86

Source: Authors.

The selection of interview respondents was conducted to ensure representation of both men and women. However, in practice, agricultural production in Viet Nam is predominantly carried out by men, particularly in rice farming within the Mekong River Delta. As a result, male respondents constituted the majority, accounting for 62.14% of the survey sample (Table 10.3).

10.3 Data Analysis and Interpretation

10.3.1 Profile of Respondents

The majority of interview respondents have extensive experience in agricultural production. As shown in Table 10.4, nearly 47% of respondents have more than 20 years of experience, whilst those with less than 5 years of experience account for less than 12%. Farmers mostly have more than 20 years of experience. Meanwhile, wholesalers, co-operatives and consumers have many years of experience ranging from 5 years or more. Businesses have 11–20 years of experience, and technology suppliers also have 5–10 years of experience.

Table 10.4. Experience Classification by Stakeholder Type (%)

No.	Stakeholder	<5 years	5–10 years	11–20 years	>20 years
1	Farmers	14.29	8.33	26.19	51.19
2	Wholesalers	0.00	20.00	40.00	40.00
3	Businesses	0.00	0.00	100.00	0.00
4	Distributors	0.00	100.00	0.00	0.00
5	Co-operatives	0.00	40.00	20.00	40.00
6	Technology providers	0.00	100	0.00	0.00
7	Consumers	0.00	50.00	50.00	0.00
8	Others*	0.00	50.00	0.00	50.00
	All	**11.65**	**13.59**	**28.16**	**46.60**

* Processing facility.

Source: Authors.

The years of experience amongst stakeholders in the value chain are relatively similar, with most having at least 5 years of experience in their respective fields and many possessing over 20 years of experience. The majority of these stakeholders exhibit a high degree of specialisation and rarely change occupations; therefore, their years of experience are primarily correlated with their age (Table 10.5).

Table 10.5. Classification of Experience by Main Product (%)

No.	Main product	< 5years	5–10 years	11–20 years	>20 years
1	Paddy	12.37	11.34	28.87	47.42
2	Fruits/vegetables (traditional)	0.00	50.00	50.00	0.00
3	Livestock and poultry	0.00	0.00	0.00	100.00
4	Aquaculture	0.00	0.00	0.00	0.00
5	Fruits/vegetables (greenhouse)	0.00	0.00	0.00	0.00
6	Others	0.00	66.67	0.00	33.33

Source: Authors.

By product category, rice farmers exhibit the greatest diversity in years of experience, ranging from less than 5 years to more than 20 years (Table 10.5). This is partly due to the larger sample size for the rice sector, resulting in a more varied distribution of experience levels. In contrast, other sectors have smaller sample sizes, leading to lower representativeness in the results.

Table 10.6. Classification of Farmers Participating in Rice Products by Farm Size

No.	Farm size (hectares)	Share (%)
1	<0.5	35.71
2	0.5–3	50.00
3	>3	14.29

Source: Authors.

The scale of rice farms in Viet Nam remains relatively small. As seen in Table 10.6, over 35% of households cultivate less than 0.5 hectares (ha) of rice fields, primarily in the northern region. In contrast, farms in the southern region tend to be larger, with an average size of 1–2 ha per household. Approximately 50% of households have farm sizes ranging from 0.5 to 3 ha, whilst nearly 15% cultivate more than 3 ha of rice land.

Table 10.7. Classification of Educational Level by Stakeholder Type (%)

No.	Stakeholder	Elementary	Secondary/high school	Vocational/ elementary	Higher
1	Farmers	16.67	73.81	3.57	5.95
2	Wholesalers	0.00	100.00	0.00	0.00
3	Businesses	0.00	33.33	0.00	66.67
4	Distributors	0.00	0.00	0.00	100.00
5	Co-operatives	0.00	0.00	20.00	80.00
6	Technology providers	0.00	0.00	0.00	100.00
7	Consumer	0.00	0.00	0.00	100.00
8	Others*	0.00	50.00	50.00	-
9	**All**	**13.59**	**66.99**	**4.85**	**14.56**

* Processing facility.
Source: Authors.

Low educational attainment is one of the major barriers to digital transformation in Viet Nam's agricultural sector. Statistics indicate that less than 10% of farming households have received vocational training or higher education. The majority have only completed lower or upper secondary education, whilst nearly 17% of the surveyed farmers have only completed elementary education. In contrast, other stakeholder groups have significantly higher educational levels, with most having attended short-term vocational training programmes or obtained a university degree (Table 10.7).

10.3.2 Current Status

10.3.2.1 Application of Digital Agriculture

Vietnamese agriculture has integrated various technologies into production, processing, and product commercialisation. With the exception of robotics, all other digital technologies mentioned in the survey have been adopted within Viet Nam's agricultural value chain. However, the degree of adoption and the prevalence of these technologies vary significantly (Table 10.8). Agricultural advisory applications (covering production, distribution, and consumption) are the most widely used, with approximately 52.43% of respondents, including farmers, wholesalers, enterprises, co-operatives, and technology providers, reporting their use. Amongst them, nearly 54% of surveyed farmers utilise these applications, predominantly in the southern region. Notable examples include advisory platforms developed by Lộc Trời Group, such as the Nông dân Lộc Trời app for farmers and the Đại lý Lộc Trời app for co-operatives and wholesalers, as well as the MEKONG RYNAN application by RYNAN Technologies Viet Nam.

Drones represent the second most adopted technology, with approximately 50% of respondents reporting usage. In agriculture, drones are employed in various activities, including rice seeding, fertilisation, pesticide spraying, irrigation, field monitoring, pest surveillance, and yield forecasting. Currently, most farmers in the Mekong Delta are familiar with using drones for fertilisation and pesticide spraying, whereas adoption remains limited in northern Viet Nam. This discrepancy is largely due to differences in farm sizes; in the south, agricultural production is relatively large-scale, with the average farm size amongst surveyed households in An Giang being 2.8 hectares, whereas farms in the north are significantly smaller on average (Nam Định, 0.1 ha; Ha Noi, 0.27 ha; Bắc Giang, 0.67 ha).

Other technologies, such as IoT, automation, geographic information systems (GIS), artificial intelligence (AI), precision agriculture, and big data, are primarily adopted by co-operatives, businesses, and technology providers. As costs continue to decline and availability increases, these technologies are becoming more prevalent, particularly in the Mekong Delta, the largest commercial agricultural production region in Viet Nam.

Table 10.8. Rate of Application of Digital Technologies and Digital Tools in Agricultural Production by Actor (%)

No.	Technology	Farn	Who	es Busi	s Distr	erati op Co	pro Techn	Cons	All
1	Farming advisory apps	53.57	40.00	100.00	0.00	60.00	100.00	0.00	52.43
2	Drones	54.76	0.00	33.33	1.96	60.00	0.00	0.00	49.51
3	IoT sensors	0.00	0.00	66.67	0.00	20.00	100.00	0.00	3.88
4	Robotics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Automation	0.00	0.00	66.67	33.3	0.00	100.00	0.00	3.88
6	Remote sensing and geographic information systems	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.97
7	Artificial intelligence	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.97
8	Precision agriculture	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.97
9	Data management software	0.00	0.00	66.67	0.00	60.00	100.00	0.00	5.83

Source: Authors.

The group of applications related to distribution, marketing, and finance has been widely adopted, particularly digital payment tools. According to the State Bank of Viet Nam, many financial institutions conduct over 90% of their transactions through digital channels, with approximately 77.41% of the adult population holding a bank account and more than 35 million active payment accounts (Minh Ánh, 2024). Given that the survey respondents were already users of digital tools, most of them reported having a bank account and having installed digital banking applications.

The survey results (Table 10.9) indicate that nearly 48% of respondents use digital applications for financial transactions between suppliers and buyers, whilst 40% utilise digital banking payment systems. This suggests that although the majority of respondents own smartphones and bank accounts, cash transactions remain a common practice for more than 50% of them. Meanwhile, despite e-commerce being recognised as an inevitable development trend and having experienced rapid growth in recent years, its application in the agricultural sector remains relatively limited. Currently, the e-commerce market accounts for approximately 10% of total retail goods and consumer service revenue, up from 8.5% in 2022. It is projected that Viet Nam's e-commerce sector will continue its strong expansion, with gross merchandise value expected to reach US$16.8 billion by 2025 (Virac Research, 2024). However, only about 8% of respondents reported using digital marketplaces for agricultural production and consumption needs.

Table 10.9. Rate of Adoption of Digital Technologies and Digital Tools in Distribution, Marketing, and Finance by Actor (%)

No.	Stakeholder	Digital marketplace	Digital apps for financing and payment amongst suppliers and buyers	Digital payment systems with banks
1	Farmers	4.76	36.90	30.95
2	Wholesalers	0.00	80.00	60.00
3	Processors	33.33	100.00	100.00
4	Distributors	100.00	100.00	100.00
5	Co-operatives	20.00	80.00	40.00
6	Technology providers	100.00	100.00	100.00
7	Consumers	0.00	100.00	100.00
8	All	7.77	47.57	39.81

Source: Authors.

Digital technologies and tools in distribution, marketing, and finance have been integrated across the entire supply chain, particularly in commercial transactions. In 2023, mobile payments increased by 59.86% in volume and 12.73% in value, whilst QR code payments surged by 242.46% in volume and 157.2% in value compared with the same period in 2022 (Trần Ngọc, 2024). This trend is also evident in the agricultural sector, where most stores, wholesalers, and distributors have adopted QR code payments or bank transfers. According to the survey, nearly 37% of farming households use digital applications to pay for agricultural inputs or receive payments from traders, whilst 31% conduct credit transactions through banking applications. Notably, nearly 100% of the remaining stakeholders in the agricultural value chain utilise banking applications for money transfers.

However, the adoption of digital technologies for farm product traceability in both domestic and international markets remains limited in Viet Nam. Amongst the 103 survey respondents (Table 10.10), none reported using blockchain technology to verify product information and manage logistics. Only about 1% indicated the use of sensors and IoT-based systems for agricultural product classification, whilst more than 17% applied QR codes or barcodes embedded with product information. This presents a significant challenge for Vietnamese agriculture, as product traceability has become an essential requirement in global supply chains. In Viet Nam, the demand for transparent product information is increasing due to economic integration and stringent regulations from international markets such as the European Union, the United States (Government Information Portal, 2025), and China (Ngọc Ánh and Thùy Linh, 2025).

Table 10.10. Rate of Application of Digital Technologies and Digital Tools in Digital Traceability of Farm Goods in Domestic and International Markets

No.	Digital technology or tool	Share (%)
1	Application of sensors and IoT-based systems for sorting farm produce	0.97
2	Blockchain technologies to identify product and logistics information	0.00
3	Inbuilt QR codes or barcodes containing product information	17.48

Source: Authors.

The adoption of traceability technology in the agricultural value chain remains inconsistent. By nature, traceability aims to collect information throughout the production, processing, and consumption stages. However, current traceability technologies are primarily implemented in processing and commercial activities, whilst their adoption in the production phase remains significantly limited. Specifically, most post-production stakeholders have a high adoption rate of QR codes or barcodes embedded with product information (67%–100%). In contrast, adoption rates amongst producers remain low, with co-operatives at 40% and farmers at only about 12% (Table 10.11).

Table 10.11. Application Rate of Inbuilt QR Codes or Barcodes Containing Product Information in Digital Traceability of Farm Goods in Domestic and International Markets by Actor

No.	Stakeholder	Share (%)
1	Farmers	11.90
2	Wholesalers	0.00
3	Businesses	66.67
4	Distributors	100.00
5	Co-operatives	40.00
6	Technology providers	100.00
7	Consumers	100.00

Source: Authors.

10.3.2.2 Stakeholders' Willingness to Adopt Digital Technologies

Overall, stakeholders in Viet Nam's agricultural value chain express interest in and willingness to adopt digital technologies (Table 10.12). All proposed technological solutions were selected by the survey respondents. Notably, solutions that provide direct support to agricultural production received the highest level of interest, including increasing agricultural yield and productivity (85% of respondents), reducing production/operational costs (85%), promoting environmentally friendly agricultural practices (59%), and optimising labour efficiency in activities such as irrigation, fertilisation, and livestock feeding (55%).

In contrast, more complex and indirectly impactful technological solutions received less attention, highlighting the limitations of current outreach efforts. For instance, only 9.7% of respondents expressed interest in adopting data management technologies, including data collection, analysis, storage, transfer, and sharing. This is concerning, as big data is not only a fundamental component of the Fourth Industrial Revolution but also serves as the backbone for key transformative technologies such as AI, machine learning, robotics, IoT, and blockchain.

Big data also plays a crucial role in enabling scientists, businesses, and policymakers to make informed decisions, develop effective solutions, and enhance service quality, ultimately improving human well-being. Furthermore, it has fuelled the growth of a global market worth hundreds of billions of US dollars annually (Khôi Nguyên et al., 2025) and has been demonstrated as a powerful tool in agriculture through numerous scientific studies (Yu and Migliaccio, 2023; Cravero et al., 2022; Chergui and Kechadi, 2022). These findings indicate that many stakeholders have yet to fully grasp the value of technological solutions in the agriculture and food value chain.

Table 10.12. Share of Respondents Wanting to Apply Digital Solutions to Areas in the Agriculture and Food Value Chain

No.	Area	Share (%)
1	Increasing agricultural production and productivity	85.44
2	Reducing production/operation costs	85.44
3	Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding	55.34
4	Dealing with labour shortages	17.48
5	Enhancing the quality of farm production	24.27
6	Reducing post-harvest losses, and food loss and waste	38.83
7	Mitigating the impact of climate change (floods, droughts, etc.)	17.48
8	Promoting more environmentally friendly agriculture, including the reduction of greenhouse gas emissions	59.22
9	Exploring new marketing opportunities	20.39
10	Increasing food safety	24.27
11	Assuring consumers of the origin and quality of products	22.33
12	Data management: data collection, analysis, storage, transfer, and sharing	9.71
13	Applying for support, such as subsidies and insurance, in agriculture (e.g. e-government platforms)	13.59
14	Others*	0.97

* Advertisement.
Source: Authors.

10.3.2.3 Reasons for Using Digital Agriculture

Overall, awareness of and interest in technological solutions vary significantly amongst different respondent groups (Table 10.13). Farmers primarily seek technologies that support production, reduce labour, and increase income, whereas other stakeholder groups demonstrate a broader interest in digital solutions. Specifically, more than 90% of farmers expressed a strong desire for technologies that enhance agricultural yield and productivity whilst reducing production and operational costs. Additionally, they showed interest in labour-saving solutions in agricultural production (58.33%) and post-harvest loss and food waste reduction (36.90%). Wholesalers prioritised reducing production and operational costs (100%) alongside increasing agricultural yield and productivity (80%). They were also interested in labour-saving measures (60%) and exploring new marketing opportunities (60%).

Enterprises aimed to leverage digital solutions to enhance food safety (100%) and mitigate the effects of climate change (100%). They also focused on improving agricultural product quality (66.67%) and expanding marketing opportunities (66.67%). Distributors exhibited a strong interest in adopting digital solutions across nearly all aspects of the agriculture and food value chain (100%). This included increasing production, reducing costs, saving labour, addressing labour shortages, enhancing product quality, minimising post-harvest losses, reducing climate change impacts, promoting environmentally friendly agricultural practices, exploring new marketing opportunities, ensuring food safety, improving traceability, and managing data efficiently.

Co-operatives primarily focused on increasing agricultural yield and productivity (80%) and reducing production/operational costs (60%). They also showed moderate interest in labour-saving solutions (40%) and post-harvest loss reduction (60%). Technology providers aimed to adopt digital solutions to boost productivity, lower costs, save labour, enhance product quality, and optimise data management. Finally, consumers demonstrated particularly high interest in improving agricultural product quality (100%), enhancing food safety (100%), and ensuring product traceability (100%).

Table 10.13. Share of Actors Wanting to Apply Digital Solutions to Areas in the Agriculture and Food Value Chain (%)

No.	Area	Farn	s Whol	es Busi	s Distr	erat op Co	pro Techn	Cons
1	Increasing agricultural production and productivity	90.48	80.00	66.67	100.00	80.00	100.00	0.00
2	Reducing production/operation costs	90.48	100.00	33.33	100.00	60.00	100.00	0.00
3	Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding	58.33	60.00	33.33	100.00	40.00	100.00	0.00
4	Dealing with labour shortages	16.67	20.00	66.67	100.00	0.00	0.00	0.00
5	Enhancing the quality of farm production	20.24	40.00	66.67	100.00	0.00	100.00	100.00
6	Reducing post-harvest losses, and food loss and waste	36.90	40.00	33.33	100.00	60.00	0.00	50.00
7	Mitigating the impact of climate change	15.48	20.00	100.00	100.00	0.00	0.00	0.00
8	Promoting more environmentally friendly agriculture, including the reduction of greenhouse gas emissions	63.10	20.00	33.33	100.00	60.00	100.00	50.00
9	Exploring new marketing opportunities	14.29	60.00	66.67	100.00	40.00	0.00	0.00
10	Increasing food safety	15.48	40.00	100.00	100.00	40.00	0.00	100.00
11	Assuring consumers of the origin and quality of products	15.48	40.00	33.33	100.00	20.00	100.00	100.00

12	Data management: data collection, analysis, storage, transfer, and sharing	5.95	20.00	66.67	100.00	0.00	100.00	0.00
13	Applying for support, such as subsidies and insurance, in agriculture	13.10	20.00	0.00	100.00	20.00	0.00	0.00
14	Others*	0.00	0.00	0.00	0.00	20.00	0.00	0.00

* Advertisement.

Source: Authors.

10.3.2.4 Challenges

Although respondents expressed a strong desire to adopt various technological solutions, they also highlighted multiple challenges and barriers to implementation (Table 10.14). The primary difficulties include a lack of basic infrastructure (accessibility and affordability), shortages in human resources, financial and institutional constraints, and difficulties in managing digitalised data and information transfer.

Regarding infrastructure, the two most significant challenges identified were the low level of mechanisation and the small land sizes of farmers. More than 50% of respondents stated that mechanisation remains underdeveloped, whilst nearly 43% considered small farm sizes a major obstacle. As previously analysed, the Mekong Delta region has a larger average farmland size (2.8 ha per household), leading to a significantly higher adoption rate of mechanisation (e.g. drones) and digital technology compared to the northern region, which averages only 0.1–0.67 ha per household. These findings suggest that these two factors are the biggest bottlenecks in the adoption of technology in Viet Nam.

Furthermore, different stakeholder groups expressed specific concerns (Table 10.15). Wholesalers were mainly concerned about access to broadband Internet (60%) and underdeveloped mechanisation, including a lack of equipment and tools (60%). Businesses cited the lack of mechanisation, equipment, and tools (66.67%) and small farm sizes (33.33%) as key barriers to adopting digital technology. Distributors identified the most significant challenges as underdeveloped mechanisation, lack of equipment and tools (100%), limited access to broadband internet (100%), small farm sizes (100%), and the impact of natural disasters due to climate change (100%). Co-operatives expressed concerns about the low level of mechanisation and lack of equipment and tools (60%), small farmland sizes (60%), and climate-related disasters (20%). Technology providers were primarily worried about the lack of mechanisation, equipment, and tools. Consumers were particularly concerned about underdeveloped mechanisation and a lack of equipment and tools (100%), small farm sizes (100%), and access to broadband internet (50%).

Table 10.14. Challenges, Limitations, and Infrastructure Obstacles When Applying Digital Technology and Digital Tools

Challenge	Share (%)
Availability of uninterrupted electricity supply	5.83
Access to broadband internet access	20.39
Farmers' land size	42.72
Climate-induced natural disasters, including frequent floods, droughts, and landslides	25.27
Underdeveloped mechanisation (lack of equipment and tools)	50.49

Source: Authors.

More than 47% of farmers said that underdeveloped mechanisation and a lack of equipment and tools are infrastructure challenges when applying digital technology. In addition, land area (42.86%) is also one of the major challenges. Wholesalers are mainly concerned about access to broadband internet (60%) and underdeveloped mechanisation, including a lack of equipment and tools (60%). Businesses said that underdeveloped mechanisation, including a lack of equipment and tools (66.67%), and farmers' land size (33.33 %) are obstacles to applying digital technology. Distributors said that the constraints include underdeveloped mechanisation, lack of equipment and tools (100%), access to broadband internet (100%), farmers' land size (100%), and natural disasters due to climate change (100%). Co-operatives are concerned about underdeveloped mechanisation, including a lack of equipment and tools (60%), farmers' land area (60%), and natural disasters due to climate change (20%). Technology suppliers are mainly concerned about underdeveloped mechanisation and a lack of equipment and tools. Consumers are concerned about underdeveloped mechanisation and a lack of equipment and tools (100%), farmers' land area (100%), and access to broadband internet (50%).

Table 10.15. Challenges, Limitations, and Infrastructure Obstacles When Applying Digital Technology and Digital Tools by Actor (%)

Challenge	Farm	s Whol	es Busir	s Distr	erat op Co	Tech	Cons	All
Availability of uninterrupted electricity supply	5.95	0.00	0.00	0.00	0.00	0.00	0.00	5.83
Access to broadband internet access	19.05	60.00	0.00	100.00	0.00	0.00	50.00	20.39
Farmers' land size	42.86	20.00	33.33	100.00	60.00	0.00	100	42.72

Climate-induced natural disasters, including frequent floods, droughts, and landslides	27.38	0.00	0.00	100.00	20.00	0.00	0.00	25.27
Underdeveloped mechanisation (lack of equipment and tools)	47.62	60.00	66.67	100.00	60.00	100	100.00	50.49

Source: Authors.

Regarding challenges related to human resources, the survey results indicate that whilst most respondents are willing to adopt and embrace technology, they struggle with a lack of knowledge and high-quality personnel (Table 10.16). Only about 9% of respondents identified a conservative mindset or resistance to change as a barrier to technology adoption. In contrast, the biggest concern is the shortage of personnel with expertise in existing and emerging digital technologies in the agricultural sector, highlighted by 72% of respondents.

In reality, 81% of respondents and more than 90% of interviewed farmers have only primary or lower secondary education. This poses significant challenges for them in learning, exploring, and utilising complex technologies. Furthermore, respondents pointed out specific difficulties in training, including that more than 50% believe there is a shortage of agricultural extension officers and digital technology service providers with the necessary digital skills. Some 30% identified a lack of digital skills or training along the value chain, whilst 29% pointed out a lack of digital skills or training at the farm level. These findings highlight the urgent need to enhance digital literacy and technical training for workers in the agricultural sector.

Different stakeholder groups in the value chain have varying perspectives on the challenges of technology adoption. However, they generally agree that a lack of knowledge is the most significant obstacle. More than 72% of farmers consider the lack of digital literacy in both existing and emerging technologies to be one of the major human resource challenges when adopting digital technology. Additionally, 55.95% believe that the shortage of skilled digital service providers and personnel is another major barrier. Approximately 80% of wholesalers identify low digital literacy and the lack of digital skills or training along the value chain as the biggest challenges. Similarly, businesses (processors) are particularly concerned about digital literacy (66.67%) and the lack of digital skills or training at the farm level (66.67%).

Distributors perceive all these challenges as barriers to human resource readiness for digital technology adoption. Amongst co-operatives, 60% express concerns about digital literacy, another 60% about the shortage of skilled digital service providers, and 40% see the lack of digital skills or training along the value chain as a significant challenge.

Technology providers highlight the shortage of skilled personnel and digital service providers as their primary concern. Meanwhile, consumers consider digital literacy to be the most critical challenge (100%). These findings underscore the urgent need to enhance digital literacy and specialised training across the entire agricultural value chain.

Table 10.16. Challenges, Limitations, and Human Resource Obstacles When Applying Digital Technology and Digital Tools by Actor (%)

Challenge	Farr	s Whc	Bus	s Distr	erat op Co	Techn pro	Cons	All
Digital literacy regarding available and potential digital technologies	72.62	80.00	66.67	100.00	60.00	0.00	100.00	71.84
Lack of extension workers and digital technology service providers with digital skills	55.95	0.00	0.00	0.00	60.00	100.00	0.00	50.49
Lack of digital skills or training at the farm level	29.76	40.00	66.67	100.00	0.00	0.00	0.00	29.13
Lack of digital skills or training along the value chain	26.19	80.00	33.33	100.00	40.00	0.00	0.00	30.10
Conservative attitudes, such as resistance to change	5.95	20.00	0.00	100.00	20.00	0.00	0.00	8.74

Source: Authors.

In addition to human resources, 100% of survey respondents identified financial constraints as a major challenge to the widespread adoption of digital technology. Amongst these, the high cost of technology adoption was the most significant financial barrier, with 93% of respondents highlighting it as the biggest concern (Table 10.17).

According to the General Statistics Office, in 2023, Viet Nam's average monthly income was nearly D5 million, whilst income from agriculture, forestry, and fisheries was only D502,000 per month. Meanwhile, digital technologies remain expensive. For instance, a fertiliser and pesticide spraying drone costs over D200 million (Dong Nai Newspaper, 2024), which is equivalent to more than 3 years of total income for an average individual or over 33 years' worth of agricultural income. As a result, most widely adopted technologies require business investment and large-scale applications. More localised technologies, such as sensors and IoT, are less common and mainly used in high-value agricultural sectors such as aquaculture.

Due to high adoption costs, most respondents reported struggling to invest, whilst 29% of respondents cited a lack of financial incentives for infrastructure development and training programmes. Additionally, 16% noted limited public support for promoting digital technology, and 5% reported difficulties in accessing preferential loans and credit.

Overall, the different value chain actors had similar views on the financial challenges of adopting digital technology. Nearly 93% of farmers considered high costs to be the biggest financial barrier. All wholesalers regarded high adoption costs as a major issue. Over 67% of businesses cited both high costs and the lack of financial incentives for infrastructure and training as key challenges. Distributors were concerned about multiple issues, including high costs, lack of financial incentives, and limited government support. All co-operatives identified high costs as the most significant challenge. Technology providers were primarily concerned with investment costs and the lack of financial incentives for infrastructure and training. Similarly, all consumers saw high costs as the biggest barrier to accessing technology-enabled agricultural products.

Table 10.17. Financial Challenges, Limitations, and Obstacles When Applying Digital Technology and Digital Tools (%)

Challenge	Farr	s Who	Bus	s Distr	erati op Co	pro Techn	Cons	All
High cost of adopting new technologies	92.86	100.00	66.67	100.00	100.00	100.00	100.00	93.20
Lack of financial incentives for developing infrastructure and training programmes	29.76	0.00	66.67	100.00	20.00	100.00	0.00	29.13
Limited public support for the uptake of digital technology	14.29	0.00	0.00	100.00	20.00	0.00	0.00	15.53
Access to concessionary loans and credit	5.95	0.00	0.00	0.00	0.00	0.00	0.00	4.85
Others	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.97

Source: Authors.

Institutional constraints have been identified as significant barriers to the widespread adoption of digital technology, particularly regarding policy frameworks and support mechanisms for agricultural digitalisation (Table 10.18). The Vietnamese government has recognised the importance of digital transformation, especially in the context of the Fourth Industrial Revolution. On 31 December 2020, the Prime Minister issued the national strategy for the Fourth Industrial Revolution to 2030. Since then, numerous policies have been introduced to promote digital transformation, including in the agricultural sector.

Table 10.18. Institutional Challenges, Limitations, and Obstacles When Applying Digital Technology and Digital Tools (%)

Challenge	Farm	s Who	es Busi	s Distri	erati op Co	prov Techno	Cor	All
Limited policy instruments and framework conditions that support agricultural digitalisation	64.29	40.00	66.67	0.00	60.00	100.00	0.00	60.19
Lack of intergovernmental co-ordination and/or organisational structure	3.57	0.00	0.00	0.00	40.00	100.00	0.00	5.83
Inconsistent government strategies and frequent changes in farm policy	7.14	0.00	0.00	0.00	0.00	0.00	0.00	5.83
Lack of co-ordinated operations amongst public–private and local stakeholders	25.00	40.00	33.33	100.00	40.00	100.00	0.00	28.16
Others*	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.97

* Lack of implementation from government agencies.
Source: Authors.

However, shown in Table 10.18, more than 64% of farmers perceive restrictive policies and inadequate institutional frameworks as major institutional challenges in adopting digital technology. Similarly, about 40% of wholesalers consider these policy limitations, along with a lack of co-ordination between public–private stakeholders and local authorities, to be significant obstacles. More than 66% of businesses also identify policy constraints and weak institutional support for digitalisation as persistent challenges. Distributors report major difficulties due to insufficient co-ordination amongst public and private sector actors and local authorities. Co-operatives face challenges related to restrictive policies and inadequate digitalisation frameworks (60%), as well as poor intergovernmental and organisational co-ordination (40%). Technology providers similarly highlight policy limitations and weak institutional frameworks as key challenges, in addition to insufficient co-ordination between governmental bodies and other stakeholders.

Table 10.19. Challenges, Limitations, and Obstacles in Digital Data Management and Information Transfer When Applying Digital Technology and Digital Tools (%)

Challenge	Farr	s Whc	es Bus	s Distr	erat op Co	pro Techn	Cons	All
Digitalised data availability and the cost of digitalisation	14.29	0.00	33.33	100.00	0.00	100.00	0.00	15.53
Lack of facilities for data provided by the public or private sector, such as soil maps and market information	17.86	20.00	0.00	100.00	40.00	100.00	0.00	21.36
Cybersecurity threats	58.33	40.00	66.67	0.00	60.00	0.00	0.00	55.34
Software management in local languages for data integration and data sharing	1.19	20.00	33.33	0.00	40.00	0.00	0.00	4.85

Source: Authors.

A significant portion of respondents identified challenges related to the management of digital data and information transfer. Unlike other challenges, which were acknowledged by 100% of respondents, only 81% recognised issues stemming from data management and information exchange. The primary concerns in this area are shown in Table 10.19 and include cybersecurity threats (cited by 55% of respondents), a lack of data provision infrastructure (21%), and the availability and cost of digitalisation (16%). Additionally, 5% of respondents highlighted difficulties in managing software in local languages for data integration and sharing.

Clearly, this is a substantial and pressing challenge, as evidenced by the estimated 659,000 cyberattacks nationwide in 2024. According to a report from the Department of Cybersecurity and High-Tech Crime Prevention under the Ministry of Public Security, over 74,000 cybersecurity warnings were issued for critical institutions alone, including 83 targeted advanced persistent threat campaigns (VTV, 2024). These findings underscore the urgent need for robust cybersecurity measures and improved data management infrastructure to facilitate the secure and efficient adoption of digital technology in agriculture.

10.3.2.5 Private Sector Involvement

As analysed above, the adoption of technology requires the participation of private enterprises due to high investment costs. However, the level of support from the private sector remains very low, leading to limited technology adoption. According to the survey results, only 5% of respondents received direct support for technology adoption from private enterprises, whilst 93% reported receiving no support, and 2% were uncertain (Table 10.20).

Table 10.20. Private Sector Support Received for the Adoption of Digital Technologies and Tools

Support received	Share (%)
Yes	4.85
No	93.20
Unsure	1.94

Source: Authors.

The primary reason for this is that businesses typically invest in technology and provide farmers with paid services rather than direct financial support. For example, Lộc Trời Group invests in agricultural drones and offers spraying services for a fee to farmers who need them. Financial support for purchasing technological solutions, training, or equipment demonstrations is limited to a small group of beneficiaries, usually through pilot models (Table 10.22). These forms of support may come from various types of private sector entities, including multinational corporations, local agribusinesses, startups, and subsidiaries of retail companies (either buyers or intermediaries), as shown in Table 10.21.

Table 10.21. Private Sector Support Received for the Adoption of Digital Technologies and Tools by Private Sector Type

Private sector type	Share (%)
Multinational company	20.00
Local farm enterprises	20.00
Startups	40.00
Subsidiaries of retail companies (buyers or intermediaries)	20.00
Others*	60.00

* Two people received support from a co-operative and one person from the World Bank.
Source: Authors.

Table 10.22. Private Sector Support Received for the Adoption of Digital Technologies and Tools by Type of Support (%)

Support type	Share (%)
Financial support for purchasing digital technology solutions	0.00
Training to use digital services	60.00
Demonstrations for the introduction of equipment	40.00
Appropriate use of digital data services and marketplaces	20.00

Source: Authors.

12.3.2.6 Expectations of Digital Technologies

Technological solutions are expected to have a significant impact on the future of agriculture in ASEAN in the medium to long term. Amongst these, drones, one of the most widely adopted technologies today, continue to be highly regarded for their potential in transforming agricultural production. According to the survey results, 78% of respondents believe that drones will have a major impact on agriculture in the coming years (Table 10.23).

A report from Da Jiang Innovations (DJI) highlights the increasing global adoption of agricultural drones, with these devices covering more than 500 million ha of farmland worldwide by the end of June 2024. Their efficiency has resulted in substantial resource savings, including a total reduction of 210 million tonnes of water and 47,000 tonnes of pesticides. Additionally, the use of agricultural drones has significantly cut carbon emissions by approximately 25.72 million tonnes, equivalent to the carbon absorption of 1.2 billion trees, demonstrating the sustainability and environmental benefits of this innovative approach to modern agriculture (VietnamPlus, 2024).

The same report also presents findings on the effectiveness of drones in various agricultural applications. For instance, in Mexico, drone-based herbicide spraying on agave farms reduced water usage by 88% and lowered costs by more than US$60 per ha. In Australia, targeted herbicide spraying on grasslands reduced chemical usage by 51% and cut costs by 50%. In Thailand, pesticide spraying on a 1,500-tree durian orchard resulted in a 20%–30% reduction in chemical use. In South Africa, ripening agent application on small-scale sugarcane farms increased final sugar yield by up to 1.78 tonnes per ha (VietnamPlus, 2024). These examples illustrate the growing adoption of drones across ASEAN and their long-term benefits for agricultural productivity and sustainability.

Table 10.23. Share of Predicted Digital Technologies That Will Have the Greatest Impact on the Future (Medium- to Long-term) of Agriculture in ASEAN (%)

Digital technology	Farn	s Whol	es Busir	s Distr	erati op Co	prov Techno	Cons	All
Drones	85.71	60.00	33.33	100.00	40.00	0.00	50.00	77.67
IoT sensors	19.05	20.00	0.00	100.00	20.00	0.00	100.00	21.36
Artificial intelligence	25.00	0.00	100.00	100.00	40.00	100.00	50.00	30.10
Robots	32.14	60.00	33.33	100.00	20.00	100.00	50.00	35.92
Automation	33.33	60.00	33.33	100.00	20.00	100.00	50.00	36.89
Digital marketplace and e-commerce	46.43	100.00	66.67	100.00	100.00	100.00	100.00	55.34
Big data analytics	9.52	0.00	33.33	100.00	20.00	100.00	100.00	13.59
Blockchain	0.00	0.00	33.33	100.00	0.00	0.00	50.00	2.91

Source: Authors.

Apart from drones, 55% of respondents believe that the expansion of e-commerce will significantly impact ASEAN agriculture in the near future. Other technological solutions also received notable recognition, with automation (37%), robotics (36%), AI (30%), IoT (21%), and big data (14%) all seen as having considerable influence on agricultural production. However, blockchain technology was rated as impactful by only 3% of respondents. This perception, however, may need to be reconsidered. Given that most ASEAN countries have a trade surplus in agricultural exports, and destination markets are increasingly enforcing stricter traceability regulations, blockchain will likely become a crucial technology for ensuring transparency and compliance in agricultural trade.

10.4 Overview of Policies, Government Initiatives, and Programmes for Promoting the Utilisation of Digital Technologies in Agriculture and Food Systems

10.4.1 Government Policies and Initiatives

Digital agriculture transformation and the application of high technologies are pivotal to enhancing productivity, ensuring food security, and fostering sustainable development. Recognising this, the Vietnamese government has implemented several policies and initiatives aimed at promoting the integration of digital technologies into agriculture and food systems. These strategic policies focus on modernising agricultural practices, building digital ecosystems, and enhancing the competitiveness of Vietnamese agricultural products in the global market.

The National Digital Transformation Program was approved by the Prime Minister of Viet Nam on 3 June 2020 under Decision No. 749/QD-TTg. This policy aims to accelerate digital transformation across all sectors of the economy, with agriculture identified as one of eight priority sectors. The programme emphasises the development of smart agriculture and precision farming to increase the proportion of digital agriculture in the national economy. It also focuses on building big data systems for land management, automating production processes, and enhancing traceability to ensure food safety and disease control. By 2030, Viet Nam aims to become a digital nation, leveraging digital technologies to boost economic growth and innovation. In agriculture, the programme sets the foundation for building digital platforms that connect stakeholders, enhance information transparency, and support data-driven decision-making. It also encourages the application of AI, IoT, and blockchain technologies in farming practices, which are expected to improve productivity, reduce costs, and enhance sustainability.

In 2021, the Prime Minister of Viet Nam issued Decision No. 130/QD-TTg to launch the National Program on High Technology Development until 2030. This programme aims to promote research, development, and the application of high technologies across various sectors, with a special focus on agriculture. The policy encourages the use of advanced technologies such as AI, blockchain, and IoT in agricultural production to increase productivity and economic efficiency. To support this initiative, the Ministry of Agriculture and Rural Development issued Decision No. 3070/QD-BNN-KHCN in 2021, which outlines the framework for developing high-tech agriculture under this national programme. The programme focuses on building smart agriculture models that apply digital technologies for efficient resource utilisation, improving the quality of agricultural products, and enhancing food safety standards. It also promotes digital value chains linked to e-commerce platforms to provide better market access for farmers and agricultural enterprises. This initiative aims to establish digital agriculture zones and encourage public–private partnerships for technology adoption. It also develops high-tech agricultural products with high added value, contributing to the sustainable development of Viet Nam's agricultural sector.

The High-Tech Agriculture Development Plan was approved by the Prime Minister of Viet Nam in 2012 under Decision No. 176/QD-TTg and Decision No. 1895/QD-TTg. This productivity plan focuses on fostering the development of high-tech agriculture to enhance the quality and competitiveness of Vietnamese agricultural products. It emphasises the establishment of high-tech agricultural zones and the implementation of advanced production models, including precision farming, biotechnology, and automated irrigation systems. Since its implementation, the plan has contributed to the formation of high-tech agricultural regions with modern infrastructure and production techniques. It has also promoted collaboration between research institutions and enterprises, facilitating technology transfer and the commercialisation of research outcomes.

Additionally, the programme has helped to build value chains for agricultural products, enhance traceability, and meet international food safety standards.

10.4.2 Effectiveness of Government Initiatives, Programmes, and Support

Overall, government support for digital technology adoption remains limited. Only about 39% of respondents reported receiving at least one form of government assistance, with the following distribution: 12% received both financial and technical support, 1% received a combination of technical support and physical resources, 3% received only financial support, and 23% received only technical support.

Amongst those who received financial support, 87% stated that the funding was insufficient for technology implementation, whilst only 13% considered it adequate. Similarly, 76% of recipients of technical support indicated that the assistance was inadequate for adopting digital technologies, with only 24% rating it as sufficient.

In general, government support policies in Viet Nam do not fully cover the needs of businesses and individuals but instead follow a co-investment approach, requiring financial contributions from beneficiaries. As a result, the high proportion of financial aid recipients who find the support insufficient is understandable.

Table 10.24. Receipt of Government Support for Adopting Digital Technologies and Tools by Type of Support

Support type	Share (%)	Support rating: met needs (%)
Financial support	14.56	13.33
Technical support	35.92	24.32
In-kind support	0.97	0.00

Source: Authors.

Additionally, the public faces significant challenges in accessing government support policies, resulting in a low rate of policy beneficiaries. As previously analysed, despite the government's efforts to promote and support high-tech adoption, around 60% of surveyed individuals reported not receiving any assistance for technology implementation.

This situation is largely attributed to limited awareness of existing policies, as well as constraints related to policy implementation resources. Although awareness of individual policies remains low, ranging from 7.77% to 15.53% depending on the policy (Table 10.25), only 23% of respondents reported being aware of at least one policy related to digital agriculture, indicating that the majority of respondents were unaware of the government initiatives aimed at fostering high-tech agricultural development.

Table 10.25. Awareness of Policies Aimed at Applying Digital Technologies and Digital Tools (%)

Policy	Share (%)
Decision No. 749/QD-TTg issued on 3 June 2020	15.53
Decision No. 130/QD-TTg in 2021 and Decision No. 3070/QD-BNN-KHCN in 2021	13.59
Decision No. 176/QD-TTg and Decision No. 1895/QD-TTg in 2012	7.77
Other*	0.97

* Agricultural promotion policy.
Source: Authors.

Nevertheless, the majority of those aware of the policies acknowledged their supportive role in agricultural production (Table 10.26). This indicates that whilst the government has introduced well-designed policies, challenges persist in effectively communicating and implementing them amongst the public. Specifically, amongst the 24 respondents who were aware of these policies, 75% agreed that the policies provided support for their agricultural activities, whilst 21% slightly agreed (Table 10.26).

Table 10.26. Opinions on Policies Aimed at Adopting Digital Technologies and Digital Tools

Opinion	Share (%)
Agree	75.00
Slightly agree	20.80
Neither	4.20
Slightly disagree	0.00
Disagree	0.00

Note: N = 24 (people who are aware of the supporting policies for adopting digital technologies and digital tools).
Source: Authors.

10.5 Recommendations

10.5.1 Enhancing Awareness and Building Digital Capacity

Raising awareness and developing digital capacity are critical for the successful adoption of technology in agriculture. Training and capacity-building programmes should be tailored to different user groups, including farmers, agricultural co-operatives, and agribusinesses. These programmes should focus on the practical application and benefits of digital technologies such as drones, IoT sensors, data management software, and e-commerce platforms. Additionally, training initiatives should introduce other advanced technological solutions, including big data and blockchain, to help stakeholders understand their potential value.

Furthermore, strengthening the digital competencies of agricultural extension officers is essential. Providing them with digital skills and technical tools will enable them to better support farmers in adopting new technologies. Collaboration in education is equally important. Partnerships between academic institutions and technology enterprises should be encouraged to integrate digital agriculture into university curricula and vocational training programmes. This initiative will help cultivate a skilled workforce equipped with the necessary expertise to drive the digital transformation of the agricultural sector.

10.5.2 Rationalising Agricultural Production Planning

A well-structured agricultural production strategy is crucial for maximising the benefits of technology adoption. Expanding large-scale farming models can enhance the efficiency of digital and mechanised farming whilst reducing investment costs and increasing productivity. Establishing specialised farming zones will also facilitate the systematic application of digital tools.

In addition, strengthening production linkages is vital. Agricultural co-operatives and producer organisations play a key role in consolidating smallholder farms into larger operational units, making it easier to implement digital and mechanised farming practices. Enhanced collaboration amongst stakeholders will create economies of scale, further supporting the widespread adoption of digital technologies.

10.5.3 Investment in Digital Infrastructure and Data Ecosystems

The expansion of high-speed internet coverage is a fundamental prerequisite for digital agriculture. Accelerating the deployment of broadband internet, particularly in rural and large-scale farming areas, will ensure the seamless operation of digital devices and smart farming technologies.

Developing a national agricultural data ecosystem is also essential. This system should integrate critical information, including weather conditions, soil quality, market prices, and production statistics. It must be designed to be easily accessible to farmers, agribusinesses, and policymakers to support data-driven decision-making. In parallel, blockchain technology should be developed for traceability applications, ensuring transparency and reliability in the agricultural supply chain.

Additionally, cybersecurity measures must be reinforced alongside technological advancements. Governments should implement robust cybersecurity strategies to safeguard digital agricultural data from cyber threats, ensuring data privacy and integrity across the entire digital agricultural value chain.

10.5.4 Financial Support and Investment Incentives

Financial support mechanisms are essential to encourage investment in agricultural technology. Governments and technology providers should establish preferential loan programmes and subsidies to alleviate the financial burden on farmers and agribusinesses when adopting digital solutions.

Investment incentives should also be introduced to attract private sector participation in high-tech agriculture. Policies such as tax reductions, land-use incentives, and research and development grants should be implemented to encourage technological innovation and digital technology transfer. Additionally, promoting the socialisation of investment in digital agricultural equipment and supporting pilot projects for new technologies will accelerate their adoption.

10.5.5 Policy Development and Institutional Collaboration

Developing a national digital agriculture strategy aligned with Viet Nam's National Digital Transformation Program is necessary to guide the sector's transition. This strategy should emphasise precision agriculture, smart farming, and the integration of e-commerce into agricultural trade.

Enhancing policy implementation capacity is equally crucial. Government officials at all levels should receive training to effectively execute digital agricultural initiatives. Adequate funding must be allocated to approved programmes and projects, and existing policies should be streamlined to minimise redundancy and inconsistencies.

Intergovernmental and international co-operation must also be strengthened. Greater collaboration between ministries and public–private partnerships will ensure policy coherence and resource optimisation. International partnerships and regional collaborations should be promoted to share best practices and technological advancements. Leveraging international resources will further facilitate research and the application of digital technologies in agriculture.

10.5.6 Developing the Digital Agricultural Ecosystem and Strengthening the Value Chain

A well-functioning digital agricultural ecosystem is essential for optimising value chains. E-commerce platforms should be developed to connect farmers with suppliers, buyers, and consumers. These platforms should offer real-time market information, digital payment systems, and transparent supply chain tracking to enhance market efficiency.

Blockchain technology should also be widely adopted for product traceability. Encouraging the use of blockchain in supply chains will enhance transparency, ensure food safety, and strengthen consumer trust, particularly for key export products such as coffee, tea, and fruits. By implementing these comprehensive measures, ASEAN's agricultural sector can undergo a successful digital transformation, ensuring sustainability, efficiency, and resilience in the long term.

10.6 Conclusion

The rapid advancement of digital technology presents both opportunities and challenges for Viet Nam's agricultural sector. This report highlights key institutional, technical, and financial barriers hindering the widespread adoption of digital solutions. Whilst the government has demonstrated strong commitment through various policies and initiatives, gaps remain in policy implementation, digital infrastructure, data security, and stakeholder collaboration.

Survey findings reveal that limited institutional support, fragmented policy frameworks, and inadequate digital literacy amongst farmers and co-operatives continue to constrain technology adoption. Additionally, challenges related to data management, cybersecurity, and private sector engagement underscore the need for a more comprehensive and co-ordinated approach to digital transformation in agriculture. Expanding financial incentives, strengthening capacity-building programmes, and enhancing public–private partnerships are crucial for overcoming these barriers.

To foster a sustainable digital agricultural ecosystem, this study underscores the importance of high-speed internet expansion, integrated data ecosystems, and blockchain-based traceability solutions. Furthermore, targeted investment in research, innovation, and knowledge-sharing mechanisms will ensure that digital tools effectively address local agricultural needs.

Ultimately, a multi-stakeholder approach involving government agencies, private enterprises, research institutions, and international partners will be essential to accelerating Viet Nam's agricultural digitalisation. By addressing existing bottlenecks and leveraging emerging digital technologies, Viet Nam can enhance agricultural productivity, resilience, and global competitiveness in the years to come.

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Chapter 11
Conclusion and Recommendations

Masanori Kozono and Ari Aji Cahyono

11.1 Conclusion

This study aimed to assess the current utilisation of digital technologies across agricultural value chains in the Association of Southeast Asian Nations (ASEAN), identify key barriers to their diffusion, and examine enabling policy frameworks and future prospects based on empirical evidence collected through surveys and interviews. Focusing on eight countries, the study confirms that effective digitalisation cannot rely on technology deployment alone. It requires enabling environments that integrate supportive policies, targeted investments, and active stakeholder engagement. This finding reinforces the importance of aligning national digital agriculture initiatives with ASEAN-level strategies and guidelines. Continuous engagement within national governments, alongside strengthened public–private collaboration is essential to ensure practical implementation and scalable outcomes.

11.1.1 Current Status of Digital Agriculture in ASEAN

Based on the analysis from the country case studies, digital agriculture is progressing but remains uneven in ASEAN. Table 11.1 summarises the regional trends in the core elements of this study including adoption status, key adoption drivers and focus areas, challenges, and future expectations. Based on this table, the level of adoption varies significantly across countries and at different stages of the agricultural value chain. Farmers primarily focus on improving productivity, reducing costs, and easing labour constraints. Consistent with the study objectives, the findings indicate that digital technologies are most widely applied at the production stage, where farming advisory tools lead the figures, whilst adoption remains more limited in post-harvest management, traceability, financing, and integrated data systems.

Table 11.1. Synthesis of Key Findings on Digital Agriculture in the ASEAN Study

Core element	Regional pattern
Status of adoption	Digital agriculture is advancing across ASEAN but remains uneven across countries and stages of the agricultural value chain, reflecting differing levels of readiness and contextual conditions.
Adoption drivers and focus areas	Farmers primarily adopt digital technologies to improve productivity, reduce costs, and address labour constraints. Adoption is strongest at the production stage, particularly through farming advisory tools, whilst post-harvest management, traceability, financing, and integrated data systems remain less developed.

Challenges	The diffusion of digital technologies is constrained by interconnected challenges, including limited infrastructure for mechanisation, low digital literacy, high adoption costs, and fragmented institutional and policy support, which together slow the transition towards more advanced technologies.
Future outlook	Farmers show strong optimism towards market-oriented digital solutions. Digital market places are expected to play a central role in future digitalisation, followed by drones, Internet of Things-based sensors, and artificial intelligence.

Source: Authors' compilation.

Dissemination of digital agriculture continues to be hindered by various challenges, including a lack of infrastructure for mechanisation, low digital literacy, the high cost of adoption, and fragmented institutional and policy support. These constraints were consistently highlighted by respondents across countries as major obstacles to the wider diffusion of digital technologies. Moreover, these issues hamper the transition from basic digital tools to more advanced technologies that could expedite agricultural transformation.

Despite the barriers, farmers show strong optimism towards market-oriented digital solutions, indicating that improved access to buyers and digital marketplaces is expected to play a central role in the future of agriculture digitalisation in the region. It is followed by drones, Internet of Things (IoT)-based sensors and artificial intelligence (AI) as the most expected future technologies. Furthermore, support systems for digital transformation need to be strengthened, as many stakeholders perceive government and private sector assistance as limited. The study finds that existing policy frameworks often remain broad and fragmented, lacking clear implementation mechanisms, co-ordination amongst institutions, and incentive structures to support digital adoption at scale.

11.1.2 Country-level Policy Priorities for Digital Agriculture Implementation in ASEAN

Considering the unique challenges in digital agriculture implementation in the countries involved, the findings underscore that advancing digital agriculture in ASEAN requires context-specific approaches that respond to national conditions whilst remaining aligned with broader regional objectives. There are some similarities and differences amongst countries in prioritising aspects of agricultural digitalisation, as summarised in Table 11.2. It presents a comparative overview of country-specific priority areas for advancing digital agriculture across ASEAN Member States. The table highlights that all countries recognise the potential of digital technologies to support agricultural transformation. However, their areas of focus differ according to national contexts, levels of digital readiness, farming system structures, and institutional capacity, rather than reflecting a uniform pathway for digital adoption.

Several common themes emerge across countries. Strengthening implementation capacity, improving co-ordination amongst institutions, and expanding access to basic digital tools are recurring priorities, particularly in countries where digital agriculture remains at an early or transitional stage. In these contexts, emphasis is placed on low-cost, market-oriented digital solutions, enhanced extension services, and capacity building to ensure broader participation by smallholders. At the same time, countries with more established digital agriculture frameworks tend to focus on consolidating existing systems, improving affordability, and enhancing integration between digital platforms and on-farm applications.

Table 11.2. National Policy Priorities in Digital Agriculture in ASEAN

Country	Priority areas for action
Brunei Darussalam	• Scale up successful smart farming and smart aquaculture pilots beyond limited project sites • Integrate pilot-based digital solutions into regular agricultural support programmes • Improve farmer awareness and outreach to expand adoption beyond high-value subsectors
Cambodia	• Strengthen implementation capacity of existing digital agriculture policies • Translate high policy awareness into practical farm-level support through extension and training • Improve access to basic digital tools rather than introducing additional policy frameworks
Indonesia	• Improve co-ordination across ministries and programmes implementing digital agriculture • Harmonise digital platforms, data systems, and advisory services across regions • Reduce disparities in implementation outcomes between regions and farmer groups
Lao PDR	• Expand access to basic, low-cost digital solutions for smallholders • Strengthen digital tools supporting market access, advisory services, and financial inclusion • Align digital agriculture initiatives with rural development and co-operative-based approaches
Malaysia	• Improve the affordability of advanced digital technologies, including mechanisation and IoT systems • Ensure smaller farmers and small and medium-sized enterprises can participate in technology-intensive digital agriculture • Balance smart farming initiatives with inclusive access mechanisms
Philippines	• Strengthen digital marketplaces to improve farmer–buyer connectivity • Expand farmer capacity-building and digital skills development programmes • Enhance extension services to support the effective use of market-oriented digital tools

Country	Priority areas for action
Thailand	• Consolidate national data-driven platforms and digital agriculture systems • Improve integration between data platforms and on-farm digital applications • Strengthen cross-institutional co-ordination to maximise platform effectiveness
Viet Nam	• Increase policy visibility and outreach at the farm level • Strengthen extension and practical support mechanisms for farmers • Extend digital agriculture initiatives beyond export-oriented systems to include smallholders and domestic value chains

Source: Authors' compilation based on the country reports.

On the other hand, there are some essential differences in policy emphasis across countries. For example, countries like Thailand and Malaysia prioritise the consolidation and inclusiveness of more advanced, technology-intensive digital systems, whilst countries such as Lao PDR and Cambodia focus on strengthening basic digital access and institutional implementation capacity. Meanwhile, countries with large and diverse agricultural sectors, such as Indonesia, emphasise the need for improved co-ordination and harmonisation across programmes and regions.

11.2 Recommendations

Building on the empirical findings of this study, the following policy recommendations are proposed to address the key barriers to digitalisation in agriculture and food systems in ASEAN. The recommendations respond directly to the identified constraints related to infrastructure, human capacity, financing, institutional co-ordination, and policy coherence, and aim to support the effective and inclusive adoption of digital technologies across agricultural value chains. Recognising the diversity of national contexts amongst ASEAN Member States, these recommendations emphasise the need for enabling policy frameworks, targeted investments, and strengthened public–private collaboration to translate regional commitments on digital agriculture into practical and scalable national actions. The measures outlined below are intended to guide governments and relevant stakeholders in accelerating digital transformation whilst ensuring sustainability, resilience, and inclusiveness in agriculture and food systems.

1. Invest in Digital Infrastructure and Connectivity

Most countries need to address limited supporting digital infrastructure. For example, limited mechanisation and inadequate farming equipment remain key concerns for agricultural value chain actors, especially farmers. At the same time, poor internet connectivity impedes the use of digital technologies. Since the operation of such tools depends on reliable infrastructure, ensuring their availability, accessibility, and affordability is essential. National authorities, particularly ministries responsible for communication and agriculture, should work together to address these constraints.

2. Enhance Digital Skills and Capacity Building

The successful adoption of digital agriculture depends on skilled human resources. The first priority for expanding adoption is to raise farmers' digital literacy, followed by practical training to operate and apply technologies on their farms. Strengthening these competencies requires systematic capacity building with tailored curricula and effective learning methods. Governments need to embed continuous training within agricultural extension programmes. It should be formally integrated into national agricultural extension action plans.

3. Expand Access to Finance and Reduce Adoption Costs

The high upfront cost of technology remains a major barrier to adoption, particularly for smallholders, who constitute the majority of farmers in ASEAN. To address this, governments should collaborate with financial institutions to develop platforms that provide accessible credit and reduce entry barriers. Such mechanisms could offer flexible schemes, such as pay-as-you-grow or post-harvest repayment. National authorities must also ensure risk safeguards and establish measures to anticipate potential repayment failures. By promoting innovative financing, governments can foster a supportive ecosystem that brings together multiple stakeholders. For instance, involving off-takers can provide guarantees that farmers' harvests will be absorbed, reducing risks for both lenders and producers.

4. Promote Public–Private Partnerships and Innovation Ecosystems

The expansion of digital technology across the agricultural sector requires active involvement of all stakeholders, including both government and the private sector. Public agencies can play a key role in connecting technology providers, such as startups, with potential investors. In addition, collaboration with research institutes, universities, and private companies can strengthen research and development, enhancing the reliability and effectiveness of digital solutions.

5. Develop Integrated Agricultural Data Systems

Another crucial element of digitalisation is the data system. Technologies can generate diverse information, such as soil and weather data collected through IoT sensors. These datasets are vital for improving the precision of technologies and enhancing climate-related predictions. To support this, governments should establish agricultural data centres with strong security, interoperability, and well-designed architecture, drawing on data generated at the farm level.

6. Address Digital Divides through Strategic Planning and Implementation

Differences in digital capacity across and within countries have created digital divides that limit the ability of digital agriculture to scale effectively. Unequal access to infrastructure, skills, and digital services constrains farmers' participation in digital transformation, particularly in rural and remote areas. Addressing these gaps requires targeted and inclusive programmes that are designed to reach a wide range of agricultural communities. Governments play a central role in providing strategic planning and co-ordinated implementation to ensure that digital agriculture initiatives are inclusive and that no group is left behind. At the same time, greater attention to the role of the private sector is needed, as private actors are key providers of digital technologies and services. Strengthened collaboration between the public and private sectors can support wider deployment and adoption of digital solutions, helping to extend the benefits of digital agriculture across all agricultural areas in ASEAN.

7. Align National and Regional Frameworks for Coherent Implementation

ASEAN has a comprehensive regional guidance for promoting digitalisation in agriculture. The 'ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector', which were adopted at the 43rd Meeting of ASEAN Ministers on Agriculture and Forestry in October 2021 (ASEAN Secretariat, 2021), aim to provide guidance not only for ASEAN governments but also for various stakeholders in food value chains, including producers and technology users, agribusiness enterprises and key players in agri-tech industry, financial and lending institutions, and academic and research institutions. The ASEAN guidelines are comprehensive and cover various aspects, such as the use of technologies, the enabling environment, and capacity development.

The next step is to translate these guidelines into practical action plans for implementation in each country. Digitalising agriculture and food systems should be in line with the domestic agriculture situation and strategy of each country, whilst referring to agreed regional guidelines. There is no one-size-fits-all solution leading to digital transformation of the food and agriculture sector, and each country has its own priorities (Kozono, 2022).

11.3. Way Forward

Advancing digitalisation in agriculture in ASEAN requires a transition from fragmented initiatives towards more co-ordinated, scalable, and inclusive approaches. Whilst digital technologies are increasingly present across agricultural value chains, their impact is impeded by various challenges related to infrastructure, human capacity, affordability, and institutional co-ordination. These challenges can be addressed by strengthening enabling environments that integrate digital technologies into broader agricultural development, rural connectivity, and food security strategies. Greater emphasis should be placed on aligning digital initiatives with farmers' practical needs, particularly for smallholders, by prioritising low-cost, market-oriented solutions alongside sustained investment in digital skills and extension mechanisms. At the regional level, ASEAN regional co-operation can play a critical role in supporting this transition by facilitating knowledge exchange, sharing good practices, and promoting stronger coherence between national initiatives and regional strategies. ASEAN-level frameworks and guidelines provide an important reference point, but their effectiveness depends on how they are applied within national contexts. By fostering co-ordination, inclusivity, and context-sensitive implementation, ASEAN can support a more resilient digital agriculture transformation that contributes to agricultural sustainability across the region.

Following the findings of this study, an in-depth study is planned to focus on specific digital technologies with high potential impact. The study found that less than 10% of respondents in ASEAN have used AI in agriculture and along food value chains. However, over 40% of respondents in ASEAN cited AI as an expected digital technology in the future, with the figure reaching around 60% in Brunei Darussalam and Lao PDR. This implies that farmers and related stakeholders have high expectations for the future utilisation of AI in their agricultural activities and businesses. Therefore, the proposed follow-up study will concentrate on the application of AI in agri-food systems.

AI plays a critical role in enhancing the effectiveness of digital agriculture technologies by enabling data-driven decision-making. In the context of climate change, AI can support farmers by providing real-time agro-climate data analysis and early warnings to prevent crop damage and reduce yield losses. AI-enabled solutions can be integrated across multiple digital tools in agriculture, such as farm advisory applications, drones, and IoT-based soil and weather sensors. For instance, AI-powered chatbots embedded in farm advisory applications can provide farmers with guidance to optimise their farming activities. Similarly, IoT-based soil and weather sensors generate real-time field-level data that are transmitted through digital networks to centralised platforms, where AI algorithms analyse the information and produce actionable recommendations for preventing crop damage. These outputs can help farmers respond more effectively to emerging climate change risks. Considering its significance for climate change resilience efforts, the use of AI-based digital agriculture technology is important to study to understand how it works and how it can be expanded through impactful policy intervention.

References

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ANNEX

Questionnaire

Country	: ……………………………
No. respondent	: ……………………………
Enumerator name	: ……………………………

QUESTIONNAIRE

Digitalisation in Agriculture and Food Systems: Preliminary Assessment Study

Conducted by

Economic Research Institute for ASEAN and East Asia

Background and objectives

Increasing populations, weather extremes, pests, land degradation, and market disruptions are straining agriculture and food systems globally, regionally, and locally. ASEAN's projected population of 723 million by 2030 intensifies the pressure on food security, water resources, and agricultural labour. To address these challenges, the application of advanced digital technology in agriculture is essential for future resilience and productivity. As a concerted and collective initiative, the 'ASEAN Guidelines on Promoting the Utilisation of Digital Technologies for ASEAN Food and Agricultural Sector' were adopted by the ASEAN Ministers on Agriculture and Forestry in 2021. Also, in the 'ASEAN Leaders' Declaration on Strengthening Food Security and Nutrition in Response to Crises', adopted at the ASEAN Summit in September 2023, ASEAN leaders agreed to accelerate digital transformation to increase productivity and resilience in agri-food systems. Therefore, follow-up action is needed. This study is carried out as a means of reinforcing and supporting those initiatives.

The questionnaire survey formulated in this study targets farmers, technology providers, and other stakeholders, including businesses in ASEAN Member States. The objectives of the study are:

4. to assess the actual status of utilisation of digital technologies in agricultural value chains
5. to identify challenges against the diffusion of digital technology utilisation in agriculture and food systems
6. to identify and analyse digital policy instruments for strengthening agriculture policies.

Your participation in this survey is completely voluntary. All data are stored in a password-protected electronic format and can only be accessed by the project team (ERIA and (your name or your team's name)). We respect your trust and protect your privacy, and therefore will never share or present any data or personally identify you to any third parties.

We will securely store this data until the study is over. The results will be used for research purposes only. Therefore, your responses will be confidential. Completing the survey indicates your consent for the use of the answers you supply. If you have any questions about the study, please contact (your name and email address).

Respondent's Identity			
1. Name of respondent			
2. Category of respondent	a. Farmers d. Distributors g. Consumers	b. Wholesalers e. Co-operatives h. Others	c. Processors f. Technology providers
3. Main commodity	a. Rice d. Aquaculture	b. Fruits and/or vegetables (traditional) e. Fruits and/or vegetables (greenhouse)	c. Livestock and poultry f. Others ......
4. Years of experience	a. <5 years c. 11–20 years	b. 5–10 years d. >20 years	
5. Age of respondent			
6. Farm size			
7. Address			
8. Gender/sex	a. Male	b. Female	
9. Education	a. Primary c. Vocational	b. Secondary d. Higher (diploma, bachelor's, master's, doctorate)	
10. Contact number/email			

Part 1

Current status of utilising digital technologies and tools in agricultural production and along the food value chain

Q1. What sort of digital technologies and tools have you already used in your farming activities and/or activities along the food value chain? *Select all that apply*

1. Production

☐ Farming advisory apps (in production, distribution, and consumption)

☐ Drones (monitoring crop growth, spraying fertilisers and pesticides)

☐ IoT sensors

☐ Robotics

☐ Automation

☐ Remote sensing and geographic information systems (GIS)

☐ Artificial intelligence (AI)

☐ Precision agriculture

☐ Data management software

☐ Others _________

2. Distribution, marketing, and financing

☐ Digital marketplace (purchasing agriculture input, sharing farm product information, etc.)

☐ Digital apps for financing and payment amongst suppliers and buyers

☐ Digital payment system with banks

☐ Others _______

3. Digital traceability of farm commodities within domestic and international markets

☐ Application of sensors and IoT-based systems for sorting of farm produce

☐ Blockchain technologies to identify product and logistics information

☐ Inbuilt QR codes/barcodes containing product information

☐ Others _______

Q2. What are the 'needs areas' in the agriculture and food value chain to which you want to apply digital solutions? *Select all that apply*

☐ Increasing agricultural production and productivity

☐ Reducing production/operation costs

☐ Appropriate labour saving in agricultural production methods, such as irrigation, fertilisation, and feeding

☐ Dealing with labour shortages

☐ Enhancing the quality of farm produce

☐ Reducing post-harvest losses, and food loss and waste

☐ Mitigating the impacts of climate change (floods, droughts, etc.)

☐ More environmentally friendly agriculture, including reduction of greenhouse gas emissions

☐ Exploring new marketing opportunities

☐ Increasing food safety

☐ Assuring consumers of the origin and quality of products

☐ Data management: data collection, analysis, storage, transfer, and sharing

☐ Applying for support, such as subsidies and insurance, in agriculture (e.g. e-government platforms)

☐ Others _______

Q3. What are the challenges, constraints, and obstacles to using digital technologies and introducing digital solutions? *Select all that apply*

1. Basic infrastructure (accessibility and affordability)

☐ Availability of uninterrupted electricity supply

☐ Access to broadband internet access

☐ Farmers' land size

☐ Climate-induced natural disasters, such as frequent floods, droughts, landslides, etc.

☐ Underdeveloped mechanisation (lack of equipment and tools)

☐ Others _______

2. Human resources

☐ Digital literacy regarding available and potential digital technologies

☐ Lack of extension workers and digital technology service providers with digital skills

☐ Lack of digital skills or training at the farm level

☐ Lack of digital skills or training along the value chain

☐ Conservative attitudes, such as resistance to change

☐ Others _______

3. Financial

☐ High cost of adoption of new technology

☐ Lack of financial incentives for developing infrastructure and training programmes

☐ Limited public support for the uptake of digital technology

☐ Access to concessionary loans and credit

☐ Others _______

4. Institutional

☐ Limited policy instruments and framework conditions that support agriculture digitalisation

☐ Lack of intergovernmental co-ordination and/or organisational structure

☐ Inconsistent government strategies and frequent changes in farm policy

☐ Lack of co-ordinated operations amongst public–private and local stakeholders

☐ Others _______

5. Digitalised data management and information transfer

☐ Digitalised data availability and the cost of digitalisation

☐ Lack of facilities for data provided by the public or private sector, such as soil maps and market information

☐ Cybersecurity threats

☐ Software management in local languages for data integration and data sharing

☐ Others _______

Part 2

Government initiatives to support in utilising digital technologies and tools in agriculture production and along the food value chain

Q4. Have you received any support from the government for using digital technologies and introducing digital solutions? *Select all that apply*

Type of support	Did you receive the support?		In case of yes	
	Yes	No	Sufficient	Insufficient
Financial support (subsidies, access to credit, tax incentives, etc.)				
Technical support (training, education, etc.)				
In-kind support (tools, mobile phones, digital equipment, etc.)				
Others ___________				

Q5. What policies, programmes, or initiatives do you know that aim to utilise digital technologies and introduce digital solutions? *Select all that apply (country consultants should make some choices based on the existing policy in their country)*

☐ Name of policy/programme/initiative: E-commerce and online sales

Brief explanation: Promote farmers to access the market and facilitate the sale of agricultural products

☐ Name of policy/programme/initiative: Climate-smart agriculture and innovation

Brief explanation: Climate-smart agriculture and advanced technologies help farmers to reduce agricultural inputs and increase resilience, productivity, and incomes

☐ Name of policy/programme/ initiative: Digital technology communication

Brief explanation: Share market information and new technologies for future farmers

Q6. Do you agree that those policies are supportive to your activities? *Select all that apply*

☐ Agree

☐ Slightly agree

☐ Neither

☐ Slightly disagree

☐ Disagree

Part 3

Private sector support for the utilisation of digital technologies and tools in agriculture production and along the food value chain

Q7. Have you received any support from the private sector for utilising digital technologies and introducing digital solutions? *Select all that apply*

☐ Yes (Please continue to Q8)

(If yes) Which type of private sector provided it? *Select all that apply*

- o Multinational companies
- o Local farm enterprises
- o Startups
- o Subsidiaries of retail companies (buyers or intermediaries)
- o Others ______

☐ No

☐ Unsure

Q8. (If yes) What kind of support did you receive from the private sector for utilising digital technologies and introducing digital solutions? *Select all that apply*

☐ Financial support for purchasing digital technological solutions

☐ Training to use digital services

☐ Demonstrations for the introduction of equipment

☐ Appropriate use of digital data services and marketplaces

☐ Others _______

Part 4

The future of digitalisation in agriculture

Q9. What digital technologies do you think will have the biggest impact on the future (mid-to-long term) of agriculture in ASEAN? *Select all that apply*

☐ Drones

☐ IoT sensors

☐ Artificial intelligence (AI)

☐ Robots

☐ Automation

☐ Digital marketplace and e-commerce

☐ Big data analytics

☐ Blockchain

☐ Others ______